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AUTHOR Fortney, Clarence; And Others
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ABSTRACT

These instructional materials assist teachers in improving instruction on the fundamentals of welding. The following introductory information is included: use of this publication; competency profile; instructional/task analysis; related academic and workplace skills list; tools, materials, and equipment list; and 27 references. Seven units of instruction are provided on the following topics: (1) welding orientation; (2) welding safety and first aid; (3) welding tools and equipment; (4) basic metals and metallurgy; (5) basic math and measuring; (6) welding print reading; and (7) basic welding joints and symbols. Each unit contains some or all of the following sections: objective sheet; suggested activities; assignment and written test answers; written test; unit evaluation form; teacher supplements; transparency masters; information sheet; student supplements; assignment sheets; job sheets; and dissemination materials. (NLA)

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Fundamentals of Welding

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- Safety and First Aid
- Welding Orientation
- Welding Tools and Equipment
- Basic Metals and Metallurgy
- Basic Math and Measuring
- Welding Print Reading
- Basic Welding Joints and Symbols

Teacher Edition

MAVCC

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Fundamentals of Welding

Written by

Clarence Fortney
Mike Gregory
and
Larry New

Project Coordinated by

Dan Fulkerson

Developed by

The Mid-America Vocational Curriculum Consortium, Inc.

Board of Directors

Larry Nelson, South Dakota, Executive Director
Carol Fagan, Kansas, Vice-Chairman
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Ann Masters, Nebraska
Ann Benson, Oklahoma
Sylvia Clark, Texas

Jim Steward, Executive Director

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Fundamentals of Welding

Teacher Edition

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Foreword

Units of instruction in *Fundamentals of Welding* have been designed to enhance the instruction of all the welding processes. Unit 2, "Welding Safety and First Aid" merits review at regular intervals throughout the instructional process. The materials about distortion control should be taught in conjunction with any of the arc or oxyfuel welding processes. The units of instruction on "Welding Print Reading" and "Basic Welding Joints and Symbols" present applications that students will find challenging as they learn to read and interpret welding symbols.

These instructional materials have been designed to assist teachers in improving instruction. Every effort has been made to make these materials basic, readable, and by all means usable. The teacher will need to develop instructional strategies for localizing, individualizing, and supplementing the instructional materials, and to motivate the students. Special attention should be given to the teacher pages in each unit of instruction. Suggestions for teaching the unit, suggested supplemental resources, a criterion-referenced test, teacher supplements, and transparency masters are included in the teacher pages for each unit of instruction. MAVCC's format stresses basic academic and workplace skills with a strong emphasis on math and reading skills. The versatility of the format provides students requiring special math assistance with assignment sheets dedicated to single math areas.

As you use these instructional materials, we hope you will find they contribute to the improvement of the instructional process. If any problems occur or if you have any suggestions for improvement, please call us on our toll-free number (800-654-3988) or write to the Mid-America Vocational Curriculum Consortium, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

Larry Nelson, Chairman Board of Directors Mid-America Vocational Curriculum Consortium	Jim Steward Executive Director Mid-America Vocational Curriculum Consortium

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The contents of this publication were planned and reviewed by the following members of the Mid-America Vocational Curriculum Consortium Planning and Validation Committee:

Charley Brantley	Welding Instructor, Wichita Area Vo-Tech School, Wichita, Kansas
James Buhler	Head, Welding Department, Lake Area Vo-Tech Institute, Watertown, South Dakota
Joe Don Davidson	President, Oklahoma Joe's, Perry, Oklahoma
Larry New	Metal Testing Instructor, Pulaski Technical College, North Little Rock, Arkansas
Dave Roberts	Sales Manager, Majestic Metals, Denver, Colorado
Robert Pint	Owner, Winthrop Welding Works, Winthrop, Iowa
Kenneth W. Powers	Curriculum Specialist, Louisiana Technical Resource Center, Natchitoches, Louisiana
Jack Runge	Senior Design Manufacturing Engineer, Parker Hannifin Corporation, Lincoln, Nebraska

We also thank the committee which met to plan and approve the original *Introduction to Welding*. Valuable parts of that text are repeated in this book. Special thanks to the many manufacturers whose procedures and illustrations have been used as models to authenticate and enhance our test. Another thank you goes to the American Welding Society and the Lincoln Electric Company for their contributions in helping us maintain technical accuracy.

A final thank you goes to the personnel of the Oklahoma Department of Vocational-Technical Education for excellent word processing, art work, and printing.

Use of Introductory Materials

Introductory materials are included in the teacher guide only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information such as the table of contents, foreword, and acknowledgements page, information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/ learning process.
2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.
3. **Instructional/task analysis**—Provides a quick review of contents of the publication: identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.
4. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced. Skill areas reflected by skill groups, sub skills, and descriptions have been identified using *Workplace Basics: The Skills Employers Want*, developed by the American Society for Training and Development (ASTD) and the U.S. Department of Labor and adapted by MAVCC.
5. **Tools, equipment, and materials list**—Provides a comprehensive list of those items needed to successfully complete the assignment sheets and/or job sheets; assists administrator/teacher in determining program costs.
6. **Reference list**—Provides a comprehensive list of resources used in the development of this publication.

A glossary of terms may also be provided in the introductory materials depending on subject matter and committee recommendations.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Fundamentals of Welding contains seven units of instruction. Each instructional unit in a teacher guide includes some or all of the following basic components of a unit of instruction: objective sheet, suggested activities for the teacher, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, information sheet, assignment sheets, student supplements, and job sheets.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Objective sheet (Color code: White)

Each unit of instruction is based on performance objectives which state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives which state the expected performance of each student after completion of the unit of instruction, and specific objectives which state what the student must do to reach the unit objective.

The objectives should be provided for students and stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested activities (Color code: Pink)

This component is included only in the teacher guide. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teacher suggestions, and skill areas have been noted in bold. (A table of academic and workplace skills with accompanying definitions has been provided on page xv.) The teacher should read the suggested activities before teaching the units and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Instructions for evaluating student performance on the job sheets are also included in the suggested-activities section. Teachers should select and discuss with students the rating scale that will be used.

Assignment and written test answers (Color code: Pink)

Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluation of student performances.

Written test (Color code: Yellow)

This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction. The test appears in the teacher guide only, but duplication is permitted for student use. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired.

Unit evaluation form (Color code: White)

This sheet provides teachers with a record of each students performance on a unit of instruction. It includes space for assignment sheet ratings, job sheet ratings, written test scores, and teacher comments. The unit evaluation form is included in the teacher guide only, but may be duplicated.

Use of This Publication

Teacher supplements (Color code: White)

This component is included only in the teacher guide. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters (Color code: White)

Transparencies are included in the teacher guide only and are used to direct the students' attention to the topic of discussion. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Information sheet (Color code: Green)

The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements (Color code: White)

Student supplements are included in the student manual. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment sheets or job sheets.

Assignment sheets (Color code: Tan)

Assignment sheets provide students with pencil and paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets (Color code: Blue)

The job sheets provide criteria to objectively evaluate student performance, a list of required equipment and materials, and a step-by-step procedure for performing a psychomotor skill. The teacher should discuss the equipment and materials available in the classroom and/or laboratory and demonstrate the procedure prior to having students practice procedure. When a student is ready to be evaluated, the teacher should follow instructions for evaluating student performance which may be found in the teacher guide.

Job sheets are an important segment of each unit. Job sheets provide potential employers with a picture of the skills being taught during training and the performances that might reasonably be expected from an individual who has had this training.

Disseminating material

Material may be given out a unit or page at a time to keep the material before the student always new. Some teachers ask students to furnish a three-ring binder or folder for the current unit of study. This is convenient for students taking the material home to study. Upon completion, each unit is then placed in a larger binder. Some teachers prefer to store the material by unit in filing cabinets or boxes until needed.

For best results, provide student materials for each student. Student manuals contain objective sheets, information sheets, student supplements, assignment sheets, and job sheets. Students should be allowed to take their materials home at the end of the course.

Academic and Workplace Skills
(Classifications and Definitions)

Skill Groups	Sub Skills	Definitions
Learning Skills	Learning to learn	Developing ability to apply knowledge to other situations; knowing how to learn.
Foundation Skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea or fact in written form in a clear, concise manner.
	Math	Applying computation skills such as reasoning, estimation, and problem solving as they are actually used on the job.
	Science	Applying knowledge learned through study or practice that is based on scientific principles as they relate to specific tasks.
Communication Skills	Listening	Listening for content, conversation, long-term contexts, emotional meaning, and directions.
	Oral communication	Communicating a thought, idea, or fact in spoken form in a clear, concise manner.
Adaptability Skills	Creative thinking	Using imagination to create something new—i.e. an idea, invention, work of art.
	Problem solving (critical thinking)	Recognizing and defining problems, inventing, and implementing solutions, and tracking and evaluating results.
Personal Management Skills	Self-esteem	Developing self-confidence and creating a positive self-image.
	Motivation/goal setting	Setting and meeting defined goals and objectives.
	Personal and career development	Emphasizing self-direction by establishing and implementing a plan.
Group Effectiveness Skills	Interpersonal relations	Developing ability to maintain positive relations with others.
	Negotiation	Resolving conflict between two or more individuals.
	Teamwork	Working together in a group to reach a common goal.
Influence Skills	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Leadership	Directing/influencing group in performance of a specific task; accepting responsibility for others.

Fundamentals of Welding

Competency Profile

Name: ______________________________

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Option A

Rating scale:	4 -	Skilled - Can perform job with no additional training.
	3 -	Moderately Skilled - Has performed job during training program; limited additional training may be required.
	2 -	Limited Skill - Has performed job during training program; additional training is required to develop skill.
	1 -	Unskilled - Is familiar with process, but is unable to perform job.
	0 -	No Exposure - No information or practice provided during training program, complete training required.
	NA -	Non-applicable

Option B

Yes - Can perform with no additional training
No - Is unable to perform satisfactorily

_____ Unit 1: Welding Orientation

_____1. Identify welding processes.
_____2. ______________________________

_____Written Test Score

_____ Unit 2: Welding Safety and First Aid

_____1. Complete a student safety pledge.
_____2. Respond to first aid requirements.
_____3. ______________________________

_____Written Test Score

_____ Unit 3: Welding Tools and Equipment

_____1. Identify basic hand tools.
_____2. Identify basic power tools and equipment.
_____3. ______________________________

_____Written Test Score

______ Unit 4: Basic Metals and Metallurgy

______1. Identify selected metals by appearance, color, and corrosion characteristics.
______2. Conduct magnet teats to identify common metals used for welding.
______3. Conduct chisel tests to identify common metals used for welding.
______4. Conduct spark tests to identify common metals used for welding.
______5. ______________________________

______Written Test Score

______ Unit 5: Basic Math and Measuring

______1. Add, subtract, multiply, and divide fractions.
______2. Add, subtract, multiply, and divide decimal equivalents.
______3. Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms.
______4. Write fractions as decimals and percents.
______5. Write percents as decimals and fractions.
______6. Write decimals as fractions and percents.
______7. Make conversions with a decimal equivalent chart.
______8. Make conversions with an inches-to-decimal conversion chart.
______9. Measure distances with 1", ½", and ¼" graduations.
______10. Measure distances with ¼" and ⅛" graduations.
______11. Measure distances with ⅛" graduations.
______12. Measure distances with 1⁄16" graduations.
______13. Make conversions with an English-metric conversion chart.
______14. Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor.
______15. Form 90° and 45° angles with a combination square and draw parallel lines on metal stock.
______16. ______________________________

______Written Test Score

______ Unit 6: Welding Print Reading

______1. Construct a top view.
______2. Construct a front view.
______3. Construct a right side view.
______4. Construct missing hidden lines.
______5. Construct missing visible and hidden lines.
______6. Make a three-view sketch.
______7. Construct adjacent parts in an assembly section.
______8. Interpret tolerance dimensions in decimals, fractions, and degrees.
______9. ______________________________

______Written Test Score

______ Unit 7: Basic Welding Joints and Symbols

______1. Identify basic weld symbols.
______2. Interpret basic welding symbols.
______3. Interpret working welding symbols.
______4. Draw welding symbols for given specifications.
______5. Interpret a welding print and welding procedure specifications.
______6. ______________________________

______Written Test Score

COMMENTS: ______________________________

____

____

____

____

Evaluator: ______________________ Date: ______________

* **Permission to duplicate this profile is granted.**

Fundamentals of Welding

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 1: Welding Orientation	
1. Terms and definitions	11. Identify welding processes
2. Welding processes	
3. Brazing and braze welding	
4. Cutting processes	
5. Where welders work	
6. What welders earn	
7. The job outlook for welders	
8. What it takes to become a good welder	
9. Advancement potentials for welders	
10. Standards and their importance to the welding industry	
Unit 2: Welding Safety and First Aid	
1. Terms and definitions	
2. Safety color codes and their uses	
3. Accident prevention signs, their color and uses	
4. Accident prevention tags, their colors and uses	
5. The ALWAYS rules for welding safety	
6. The NEVER rules for welding safety	
7. Shop safety rules	

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
8. Eye safety	
9. Good housekeeping rules	
10. Back injuries and their causes	
11. The steps in safe lifting	
12. OSHA requirements for employers	
13. OSHA requirements for employees	
14. Rules for personal safety	
15. Personal physical and hygiene requirements	
16. Types of fires and their classifications	
17. Fire safety rules	
18. Guidelines for oxygen safety	
19. Guidelines for acetylene safety	
20. Other fuel gas safety	
21. Guidelines for shielding gas safety	
22. Rules for handling gas cylinders safely	
23. Guidelines for electrical safety	
24. Ways to recognize shock	
25. Steps in treating shock	
26. Steps in administering first aid to a victim of electrical shock	
27. First aid for minor cuts	
28. First aid for puncture wounds	
29. First aid for slivers and splinters	

	Related Information: What the Student Should Know		Application: What the Student Should Be Able to Do
30.	First aid for thermal burns	35.	Complete a student safety pledge
31.	First aid for chemical burns	36.	Respond to first aid requirements
32.	Steps in controlling bleeding		
33.	First aid for eye injury		
34.	Guidelines for general first aid emergencies		

Unit 3: Welding Tools and Equipment

1. Terms and definitions
2. Driving and chipping tools, their characteristics and uses
3. Chisels, punches, and pry bars, and their uses
4. Characteristics and uses of files
5. Types and uses of wire brushes
6. Vise-grip® clamps and their uses
7. Anchoring tools and their uses
8. Alignment tools and their uses
9. Types of jacks and their uses
10. Pulling and lifting tools, their characteristics and uses
11. Measuring tools, their characteristics and uses
12. Layout tools, their characteristics and uses
13. Turning tools and wrenches and their uses
14. Pliers and their uses

Related Information: What the Student Should Know

15. Manual cutting and shaping tools and their uses
16. Manually-operated shop tools, their characteristics and uses
17. Power equipment, its characteristics and uses
18. Power saws, their characteristics and uses
19. Positioning equipment, its characteristics and uses
20. Rules for hand tool safety
21. Rules for safe use of power tools and equipment
22. Rules for tool and equipment maintenance

Application: What the Student Should Be Able to Do

23. Identify basic hand tools
24. Identify basic power tools and equipment

Unit 4: Basic Metals and Metallurgy

1. Terms and definitions
2. Advantages of proper metal identification
3. Basic metals, and alloys their properties and their definitions
4. Metal identification tests and their characteristics
5. Mechanical properties of metals and their characteristics
6. Mechanical strengths and their characteristics
7. Physical properties of metals and their characteristics
8. Steel identification systems and their characteristics

	Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
9.	Carbon steel classifications, characteristics, and typical uses	
10.	Principal steel alloys and their uses	
11.	Alloy steel classifications, characteristics, and typical uses	
12.	Iron classifications, characteristics, and typical uses	
13.	Guidelines for identifying metals by color and characteristics	
14.	Aluminum, its characteristics and uses	
15.	Basics of the *commercial* system for identifying aluminum	
16.	The 1XXX group commercial identification system	
17.	The 2XXX plus group commercial identification system	
18.	Other elements of commercial aluminum identification	
19.	Aluminum quality designations and their meanings	
20.	Steps in using the commercial system to identify aluminum	
21.	Nonferrous metals and their typical uses	
22.	Guidelines for testing properties of metals	
23.	Equipment requirements for spark testing	
24.	Guidelines for spark testing	
25.	Characteristics of residual stresses	

Related Information: What the Student Should Know

26. Causes of residual stresses and distortion
27. Guidelines for controlling expansion and contraction
28. Routes for heat expansion from basic welds
29. Longitudinal and transverse stress in basic welds
30. Heap applications and their uses in weld quality control
31. Guidelines for preheating in special conditions
32. Methods of preheating and postheating and their applications
33. Torch preheating techniques and their applications
34. Types of steels and their recommended preheat temperatures
35. Temperature-sensing devices and their uses
36. Methods for controlling distortion with the welding process
37. Guidelines for controlling distortion with mechanical means
38. Methods of controlling distortion with restraining devices

Application: What the Student Should Be Able to Do

39. Identify selected metals by appearance, color, and corrosion characteristics
40. Conduct magnet tests to identify common metals used for welding
41. Conduct chisel tests to identify common metals used for welding
42. Conduct spark tests to identify common metals used for welding

Unit 5: Basic Math and Measuring

1. Terms and definitions
2. Basic mathematical terms and their definitions
3. Benefits of decimal equivalent charts

Related Information: What the Student Should Know

4. Benefits of an inches-to-decimal conversion chart
5. Place values of decimal equivalents and how to express them
6. Type of rules and their graduations
7. Steps in reading a scale
8. Basic geometric figures and their shapes
9. Basic geometric figures and formulas for calculating their areas
10. Squares, rectangles, and triangles and formulas for calculating their perimeters
11. Circle measurements and formulas for their calculation
12. English-metric conversion charts and how to use them
13. Methods of sizing commonly used steel stock

Application: What the Student Should Be Able to Do

14. Add, subtract, multiply, and divide fractions
15. Add, subtract, multiply, and divide decimal equivalents
16. Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms
17. Write fractions as decimals and percents
18. Write percents as decimals and fractions
19. Write decimals as fractions and percents
20. Make conversions with a decimal equivalent chart
21. Make conversions with an inches-to-decimal conversion chart
22. Measure distances with 1", ½", and ¼" graduations.
23. Measure distances with ¼" and ⅛" graduations.
24. Measure distances with ⅛" graduations.
25. Measure distances with 1⁄16" graduations.
26. Make conversions with an English-metric conversion chart.
27. Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor.
28. Form 90° and 45° angles with a combination square and draw parallel lines on metal stock.

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 6: Welding Print Reading

1. Terms and definitions
2. Basic lines and their uses
3. Basic views
4. Isometric and oblique drawings
5. Problems relating to dimensioning
6. Problems relating to tolerancing
7. Methods of dimensioning
8. Bevels and chamfers
9. Reduction and enlargement scales
10. Types of holes
11. Types of threads
12. Types of section views
13. Other symbols
14. Structural shapes
15. Requirements for a formal bill of materials
16. Requirements for an informal bill of materials

17. Construct a top view
18. Construct a front view
19. Construct a right side view
20. Construct missing hidden lines
21. Construct missing visible and hidden lines
22. Make a three-view sketch
23. Construct adjacent parts in an assembly section
24. Interpret tolerance dimension in decimals, fractions, and degrees

Unit 7: Basic Welding Joints and Symbols

1. Terms and definitions
2. Basic parts of a welding symbol
3. Arrow side, other side significance
4. Arrow line variations
5. Difference between weld symbols and welding symbols

Related Information: What the Student Should Know

6. Supplementary symbols
7. Contour and finish symbols
8. Information in a welding symbol tail
9. Basic welding joints
10. Basic welding symbols
11. Basic rules for locating dimensions
12. Additional symbols for fillet welds
13. Nondestructive testing symbols

Application: What the Student Should Be Able to Do

14. Identify basic weld symbols.
15. Interpret basic welding symbols.
16. Interpret working welding symbols.
17. Draw welding symbols for given specifications.
18. Interpret a welding print and welding procedure specifications.

Related Academic and Workplace Skills
For *Fundamentals of Welding*

Task	Skill Group	Sub Skill	Description
Unit 1: Welding Orientation			
Identify welding processes (A.S. 1)	Foundation Skills	Science	Applies knowledge learned through study to recognize scientific processes
Unit 2: Welding Safety and First Aid			
Complete a student safety pledge (A.S. 1)	Foundation Skills	Reading	Comprehends and responds to written information
Respond to first aid requirements (A.S. 2)	Adaptability Skills	Problem solving (critical thinking)	Recognizes problems and selects appropriate solutions
Unit 3: Welding Tools and Equipment			
Identify basic hand tools (A.S. 1)	Learning Skills	Learning to Learn	Develops ability to apply knowledge of shape and structure to identify hand tools
Identify basic power tools and equipment (A.S. 2)	Learning Skills	Learning to Learn	Develops ability to apply knowledge of type and use to identify power tools
Unit 4: Basic Metals and Metallurgy			
Identify metals by appearance, color, and corrosion characteristics (A.S. 1)	Foundation Skills	Science	Applies knowledge learned through study or practice that is based on scientific principles as they relate to specific conditions
Conduct magnet tests to identify common metals used for welding (A.S. 2)	Foundation Skills	Science	Applies knowledge learned through study or practice that is based on scientific principles as they relate to specific conditions
Conduct chisel tests to identify common metals used for welding (A.S. 3)	Foundation Skills	Science	Applies knowledge learned through study or practice that is based on scientific principles as they relate to specific conditions
Conduct spark tests to identify common metals used for welding (A.S. 4)	Foundation Skills	Science	Applies knowledge learned through study or practice that is based on scientific principles as they relate to specific conditions
Unit 5: Basic Math and Measuring			
Add, subtract, multiply, and divide fractions (A.S. 1)	Foundation Skills	Math	Applies computation skills to solve math problems in the welding workplace

Task	Skill Group	Sub Skill	Description
Add, subtract, multiply, and divide decimal equivalents (A.S. 2)	Foundation Skills	Math	Applies computation skills to solve math problems in the welding workplace
Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms (A.S. 3)	Foundation Skills	Math	Applies computation skills to solve math problems in the welding workplace
Write fractions as decimals and percents (A.S. 4)	Foundation Skills	Math	Applies computation skills to solve math problem in the welding workplace
Write percents as fractions and decimals (A.S. 5)	Foundation Skills	Math	Applies computation skills to solve math problems in the welding workplace
Write decimals as fractions and percents (A.S. 6)	Foundation Skills	Math	Applies computation skills to solve math problems in the welding workplace
Make conversions with a decimal conversion chart (A.S. 7)	Foundation Skills	Reading	Reads and interprets a conversion chart
	Foundation Skills	Writing	Transfers correct information from a reference source to solve a problem
Make conversions with an inches-to-decimal conversion chart (A.S. 8)	Foundation Skills	Reading	Reads and interprets a conversion chart
	Foundation Skills	Writing	Transfers correct information from a reference source to solve a problem
Measure distances with 1", ½", and ¼" graduations (A.S. 9)	Foundation Skills	Math	Applies learned measurement skills to make correct measurements in the welding workplace
Measure distances with ¼" and ⅛" graduations (A.S. 10)	Foundation Skills	Math	Applies learned measurement skills to make correct measurements in the welding workplace
Measure distances with ⅛" graduations (A.S. 11)	Foundation Skills	Math	Applies learned measurement skills to make correct measurements in the welding workplace
Measure distances with 1/16" graduations (A.S. 12)	Foundation Skills	Math	Applies learned measurement skills to make measurements for critical tolerances in the welding workplace
Make conversions with an English-metric conversion chart (A.S. 13)	Foundation Skills	Reading	Reads and interprets a conversion chart

Task	Skill Group	Sub Skill	Description
	Foundation Skills	Math	Applies multiplication skills to solve math problems in the welding workplace
Adjust a bevel square to a 45 angle using a framing square, a combination square, and a protractor (J.S. 1)	Foundation Skills	Math	Applies learned measurement skills to make angle measurements in the welding workplace
	Adaptability Skills	Problem solving (critical thinking)	Adapts computation skills to solve a related problem
Form 90° and 45° angles with a combination square and draw parallel lines on metal stock (J.S. 2)	Foundation Skills	Math	Applies learned measurement skills to make angles and lines
	Adaptability Skills	Problem solving (critical thinking)	Adapts computation skills to solve a related problem

Unit 6: Welding Print Reading

Task	Skill Group	Sub Skill	Description
Construct a top view (A.S. 1)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Construct a front view (A.S. 2)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Construct a right side view (A.S. 3)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Construct missing hidden lines (A.S. 4)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Construct missing visible and hidden lines (A.S. 5)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Make a three-view sketch (A.S. 6)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Construct adjacent parts in an assembly section (A.S. 7)	Foundation Skills	Math	Applies knowledge learned through study to incorporate math principles into a drawing
Interpret tolerance dimensions in decimals, fractions, and degrees (A.S. 8)	Foundation Skills	Math	Applies knowledge learned through study to evaluate different math structures
	Adaptability Skills	Problem solving (critical thinking)	Adapts conversion skills to solve a related problem

Unit 7: Basic Welding Joints and Symbols

Task	Skill Group	Sub Skill	Description
Identify basic weld symbols (A.S. 1)	Foundation Skills	Reading	Comprehends written and graphic information and applies it to a specific outcome

Task	Skill Group	Sub Skill	Description
Interpret basic welding symbols (A.S. 2)	Foundation Skills	Reading	Comprehends written and graphic information and applies it to a complex outcome
Interpret working welding symbols (A.S. 3)	Foundation Skills	Reading	Comprehends written and graphic information and applies it to a workplace activity
Draw welding symbols for given specifications (A.S. 4)	Foundation Skills	Writing	Communicates written and graphic information in a clear, concise manner
	Adaptability Skills	Problem solving (critical thinking)	Adapts writing and graphic skills to prepare workplace symbols
Interpret a welding print and welding procedure specifications (A.S. 5)	Foundation Skills	Reading	Comprehends written and graphic information and applies it to a workplace situation
	Adaptability Skills	Problem solving (critical thinking)	Adapts writing and graphic skills to prepare a complex workplace interpretation

Fundamentals of Welding

Tools, Equipment, and Materials List

- Assorted electrodes
- Assorted structural shapes
- Basic hand tools
    - Adjustable wrench
    - Aligning pry bar
    - Allen wrench set
    - Assorted chisels
    - Assorted files
    - Assorted jacks
    - Assorted pliers
    - Assorted screwdrivers
    - Ball peen hammer
    - Bar clamps
    - Bolt cutter
    - Box-end wrench
    - C-clamps
    - Card file
    - Center punch
    - Chipping hammer
    - Clip plates or dogs
    - Come-along
    - Cylinder wrench
    - Drift punch
    - Fitter's hammer
    - Flat bar
    - Hacksaw
    - Mallet
    - Open-end wrench
    - Pipe cutter
    - Pipe wrench
    - Plate dogs
    - Platen table and accessories
    - Prick punch
    - Sheet metal snips
    - Sledge Hammer
    - Slings
    - Socket wrench and handles
    - Spring clamps
    - Strongback
    - Torch wrench
    - Turnbuckles
    - Vise
    - Vise-Grip® clamps
    - Wedges
    - Wire brushes
    - Yoke

- Cutting and Shaping Tools
    - Angle iron cutter. notcher. and bender
    - Anvil
    - Beverly shear
    - Hossfeld bender
    - Tap and die set
- Measuring Tools
    - Bevel square
    - Calipers
    - Chalk line
    - Combination square
    - Drill point gauge
    - Framing square
    - Levels
    - Metal gauges
    - Micrometer
    - Plumb bob
    - Pocket tape
    - Rules
    - Steel tape
    - Wing dividers
- Oxyacetylene welding and cutting rig
- Power Equipment
    - Angle and straight grinders
    - Belt and disc sander
    - Cut-off saw
    - Drill press
    - Hand drill
    - Heavy-duty hand drill
    - Manipulator
    - Pedestal buffer
    - Pedestal grinder
    - Positioner
    - Power hacksaw
    - Power roll
    - Power shears
    - Press brake
    - Reciprocating saw
    - Turning rolls
    - Vertical band saw
- Safety Equipment
    - Assorted welding lenses
    - Face shield
    - Fire extinguisher(s)
    - Safety glasses
    - Welding helmet
    - Welding and cutting goggles

- Welding cables, hoses, and guns
    - FCAW
    - GMAW
    - GTAW
    - SMAW
- Welding machines

Fundamentals of Welding

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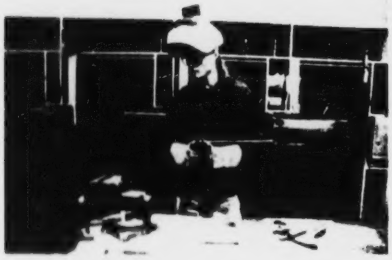


Welding Orientation
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the students should be able to discuss the importance of welding and cutting processes and identify common welding processes. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding orientation with their correct definitions.
2. Complete statements about welding processes.
3. Select true statements about brazing and braze welding.
4. Complete statements about cutting processes.
5. Select true statements about where welders work.
6. Complete statements about what welders earn.
7. Select true statements about the job outlook for welders.
8. Complete statements about what it takes to become a good welder.
9. Select career opportunities for welders.
10. Complete statements about standards and their importance to the welding industry.
11. Identify welding processes. (Assignment Sheet 1)

Welding Orientation
Unit 1

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Master Chart of Welding and Allied Processes (Objectives 2, 3, and 4)
   TM 2—Master Chart of Welding and Allied Processes Continued (Objectives 2, 3, and 4)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheet. Review criteria for evaluation of this activity.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These have been adapted by MAVCC.

1. Find a retired welder in your city or area and ask him or her to address the class about what welding has been as a career. Where was the job or where were the jobs? What were the working conditions? What was the pay? Were there company benefits? Were you welding during the busy years of World War II? What made you want to become a welder? Did welding adversely affect your health? Would you pick welding as a career if you could do it all again? Skill areas: **personal management skills, career development**.

   Note: Surveys indicate that some students think of welding as just another dirty job. Associating welding with the human aspect, the career approach, and placing it in an historical perspective may provide a very positive experience for many students.

2. Discuss the major welding processes in detail and impress upon students the advantages of having multiple welding and cutting skills in the workplace. As some job areas decline toward the end of the century, those welders with skills versatility will survive economic ups and downs. Skill areas: **personal management skills, career development**.

3. Send or call for the AWS Film Directory listed in the Suggested Supplemental Resources part of these Suggested Activities. You should order a safety film to use with Unit 2 of *Fundamentals of Welding*.

Suggested Activities

4. Talk to students about general opportunities in welding as they are outlined in this unit. Better yet, try to pinpoint special welding opportunities in your city, area, or state. Have welders from those industries talk to the class about the type of welding involved and how to plan for job opportunities. Skill areas: **personal management skills, career development**.

Resources Used in Developing This Unit

1. *Occupation Outlook Handbook 1990-91 Edition, Bulletin 2350.* Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, 1990.

2. Connor, Leonard P., ed. *Welding Handbook Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.

3. O'Brien, R. L., ed. *Welding Handbook Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.

4. Fortney, Clarence, and Mike Gregory. *Introduction to Welding.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

1. The American Welding Society's *Publications Catalog, Spring 1991*, is a valuable resource for everything from contemporary safety films to complete training programs. The catalog also includes information about WIRE and the AWS Welding Industry Referral for Employment. The WIRE program is a computerized listing of welders looking for jobs, and employers looking for welders. The *Publications Catalog* should be a required document of all welding programs. Write for a free copy or call the American Welding Society.

   The American Welding Society
   550 Northwest LeJeune Road
   P.O. Box 351040
   Miami, FL 33135
   800-443-9353

2. The American Welding Society's AWS Film Directory, 1989, is also a valuable catalog for any welding program. It covers more than 40 pages of video and film materials available form welding products manufacturers and educational curriculum facilities. Write or call the American Welding Society at the address previously given. AWS publications are available with educational discounts. Several popular welding or welding-related publications are also available and are highly recommended for instructor and student reference and reading. Instructors and students dedicated to the field of welding will appreciate all of the magazines. Their names and addresses follow in random order.

Suggested Activities

a. The *Stabilizer*® is a quarterly magazine for people interested in welding. Published by Lincoln Electric, the magazine has special features which recount welding projects by individual readers. "How I Did It" and "How I Fixed It" are regular features in the publication. Graphics and procedures are often presented in detail, and some of the projects come from vocational welding programs. For information, write to:

The Stabilizer
The Lincoln Electric Company
22787 St. Clair Avenue
Cleveland, OH 44117

b. The *Welding Journal* is the official monthly publication of the American Welding Society. Monthly "Feature Articles" present in-depth coverage of significant welding information. The "Practical Welder" section presents on-the-job applications of special interest, while the "News" section covers legislative activity in Washington, good reviews of news products, and an interesting range of departments ranging from society news to new literature. The "Research Supplement" that concludes each issue includes technical reports and papers of a more formal nature. For information write to:

Publications Director
American Welding Society
P.O. Box 351040
Miami, FL 33135
305-443-9353

c. *Welding Design and Fabrication* calls itself "The magazine of welding management and technology." Published by Penton/IPC, Inc., of Cleveland, Ohio, the magazine features articles of interest to industries that use welding processes in their activities. The magazine has feature articles on all facets of the industry, both domestic and international. For information, write to:

Welding Design and Fabrication
1111 Chester Avenue
Cleveland, OH 44114

d. *Design News*, as the name implies, is written for design engineers, but its frequent publication of articles related to metallurgy and welding, make it an important publication for companies active in welding fabrication. For information, write to:

Design News
Marketing Services
1350 Touhy Avenue
Des Plaines, IL 60018
800-323-4958

Welding Orientation
Unit 1

Answers to Assignment Sheet

Assignment Sheet 1

a. 3
b. 2
c. 4
d. 1
e. 7
f. 6
g. 5

Welding Orientation
Unit 1

Answers to Written Test

1. Answers should duplicate or approximate the following:
    - a. Base metal: The meatl of alloy that is welded, brazed, soldered, or cut
    - b. The growing together or growth into one body of the materials being welded
    - c. Fusion welding: The melting together of filler metal and base metal only, to produce a weld
    - d. Welding: A joining process that produces coalescence of materials by heating them to the welding temperature, with or without the application of pressure or by application of pressure alone, and with or without the use of filler metal

2.
    - a. With or without
    - b. The electrode
    - c. Nonconsumable
    - d. An externally supplied gas
    - e. May or may not
    - f. A blanket of granular, fusible material
    - g. Nonconsumable
    - h. May or may not

3. a, b

4.
    - a. The chemical reaction of oxygen with a base metal
    - b. Melting

5. b, c

6.
    - a. $400
    - b. $600
    - c. Company benefits

7. a, c, d

8.
    - a. Chemistry
    - b. In a few days or weeks
    - c. Eye-hand coordination
    - d. Work in awkward positions

9.
    - a. 1
    - b. 2
    - c. 2

10.
    - a. Procedures and performances
    - b. Minimums
    - c. (1) Procedure
        - (2) Brazing
        - (3) Terms and definitions

Answers to Written Test

8. a. Chemistry
   b. In a few days or weeks
   c. Eye-hand coordination
   d. Work in awkward positions

9. a. 1
   b. 2
   c. 2

10. a. Procedures and performances
    b. Minimums
    c. (1) Procedure
       (2) Brazing
       (3) Terms and definitions

Welding Orientation
Unit 1

Written Test

Name ______________________________ Score ______________

1. Define terms related to welding orientation. Write the correct definition beside the word.

   a. Base metal: ____

   ____

   b. Coalescence: ____

   ____

   c. Fusion welding: ____

   ____

   ____

   d. Welding: ____

   ____

   ____

2. Complete statements about welding processes. Circle the information that best completes each of the following statements.

   a. Oxyfuel Gas Welding (OFW)—A group of welding processes that produces coalescence by heating materials with an oxyfuel gas flame or flames, with or without pressure, and (**with**) (**with or without**) the use of filler material.

   b. Shielded Metal Arc Welding (SMAW)—An arc welding process that produces coalescence of materials by heating them with an arc between a covered electrode and a workpiece; shielding is obtained from decomposition of the electrode cover, pressure is not used, and filler metal is obtained from (**the electrode**) (**the electorde cover**)

   c. Gas Tungsten Arc Welding (GTAW)—An arc welding process that prodcues coalescence of materials by heating them with an arc between a (**nonconsumable**) (**consumable**) tungsten electrode and a workpiece; shielding is obtained from a gas, and filler metal may or may not be used

Written Test

d. Gas Metal Arc Welding (GMAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is obtained entirely from (**an externally supplied gas**) (**the reaction with the base metal**)

e. Flux-Cored Arc Welding (FCAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux contained within the tubular electrode, and additional shielding (**must**) (**may or may not**) be obtained from an externally supplied gas or gas mixture

f. Submerged arc welding (SAW)—An arc welding process that produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and a workpiece; the arc and molten metal are shielded by (**chemical reactions**) (**a blanket of granular, fusible material**) on the workpiece; pressure is not used, and filler metal is obtained from the electrode or sometimes from a supplemental source

g. Plasma Arc Welding (PAW)—An arc welding process that produces coalescence of metals by heating them with a constricted arc between a (**nonconsumable**) (**consumable**) electrode and a workpiece (transferred arc), or the electrode and a constricting nozzle (nontransferred arc)

h. In PAW, shielding is obtained from the hot, ionized gas issuing from the torch, and this may be supplemented with an auxiliary source of shielding gas; shielding gas may be an inert gas or a mixture of gases, and filler metal (**must**) (**may or may not**) be used.

3. Select true statements about brazing and braze welding. Place an "X" beside each true statement.

______ a. Brazing is a group of welding processes that produces coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having a melting point above 840°F and below the melting point of the base metal.

______ b. In brazing processes, the filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

______ c. Braze welding is a welding process variation that uses a filler metal with a melting point above 840°F and above the melting point of the base metal.

______ d. Like brazing, in braze welding, the filler metal is distributed in the joint by capillary action.

Written Test

4. Complete statements about cutting processes. Circle the information that best completes each of the following statements.

   a. Oxyfuel Gas Cutting (OFC)—A group of cutting processes used to sever metals by means of (**burning**) (**the chemical reaction of oxygen with a base metal**) at elevated temperatures; the necessary temperature is maintained by means of gas flames obtained from the combustion of a specified fuel gas and oxygen

   c. Arc Cutting (AC)—A group of cutting processes that sever or remove metal by (**melting**) (**chemical reaction**) with the heat of the arc between an electrode and the workpiece.

5. Select true statements about where welders work. Place an "X" beside each statement that is true.

   _______a. In its latest report, the Bureau of Labor Statistics reported that 3 out of 10 welding jobs are held by welders and cutters, while welding machine operators hold about 4 out of 10.

   _______b. About 6 out of 10 welding jobs are in plants that manufacture boilers, construction equipment motor vehicles, machinery, ships, appliances, and other metal products.

   _______c. About 4 out of 10 welding jobs are with firms that construct bridges, large buildings, pipelines, other structures, or repair ships.

   _______d. All welding machine operators work in robotic applications.

6. Complete statements about what welders earn. Circle the information that best completes each of the following statements.

   a. The median earning for welders and welding machine operators was about (**$400**) (**$600**) a week in the late 1980s.

   b. Beginners and lesser paid welders averaged $225 a week, but welders in the top 10 percent income bracket earned over (**$500**) (**$600**) a week.

   c. Many welders work in situations where (**company benefits**) (**top wages**) make the job more attractive, and over one-third of all welders belong to a union.

Written Test

7. Select true statements about job outlook for welders. Place an "X" beside each true statement.

   ______ a. Employment of welders and cutters in construction is expected to grow as fast as the average for all occupations through the year 2000.

   ______ b. In some areas, the need for welders will rise through the year 2000, and many job openings will arise because of the need to replace experienced workers who transfer or retire.

   ______ c. The areas that look best for good welding jobs are in construction and repair because these are areas that are difficult to automate.

   ______ d. Many jobs will be open in manufacturing, but they will be jobs in maintenance, repair, and other areas where the work cannot be automated.

8. Complete statements about what it takes to become a good welder. Circle the information that best completes each of the following statements.

   a. Training for welding should start early in high school and include courses in shop math, mechanical drawing, print reading, physics, and (**chemistry**) (**electricity**).

   b. Some welding machine operators can learn their jobs (**at special company classes**) (**in a few days or weeks**), but employers prefer applicants who have high school, vocational, and/or post-secondary training in welding.

   c. Welders and cutters need manual dexterity, good eyesight, and good (**eye-hand coordination**) (**concentration**).

   d. Good welders should also be able to concentrate on detailed work for long periods, and be able to bend, stoop, and (**work in awkward positions**) (**stand in one position a long time**).

9. Select career opportunities for welders. Circle the number of the information that best reflects each welder opportunity.

   a. A maintenance shop is looking for someone who can perform many different welding jobs. Chances are they will hire:

      (1) A combination welder
      (2) A welder-fitter who can also work with pipe
      (3) The welder who is good at GTAW

Written Test

b. A firm that makes restaurant equipment and stainless steel salad bars needs a replacement welder. They will hire:

(1) A combination welder
(2) A specialist welder, probably a GTAW specialist
(3) A welder-fitter who is good with joint preparation

c. A company is looking for a welder to supervise a field crew that will be working on a special project. Chances are they will look for an experienced supervisor, but they could:

(1) Promote from within their own labor supply
(2) Select a welder who has demonstrated leadership abilities
(3) Look for a specialist welder

10. Complete statements about standards and their importance to the welding industry. Circle the information that best completes each of the following statements.

a. In 1936, the Committee on Standard Qualification Procedures issued its first report to the American Welding Society; the report called for general qualification standards for (**procedures and performances**) (**the classification**) of welders.

b. Today, standards guide many industrial producers, and standards affecting welding are produced by other groups who have welding (**processes**) (**minimums**) that must be met and procedures that must be followed.

c. The American Welding Society has various committees who meet to update and change standards as needs require, and among these standards, three are important to all welders, including beginners:

(1) Standard for Welding (**Procedure**) (**Process**) and Performance Qualification
(2) Standards Symbols for Welding, (**Brazing**) (**Cutting**), and Nondestructive Examination
(3) Standard Welding (**Terms and Definitions**) (**Equipment**)

***Permission to duplicate this test is granted.**

Welding Orientation
Unit 1

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Identify Welding Processes Rating _____

Comments: ______________________

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ______________________

____

Teacher Signature ______________________ Date ________

Student Signature ______________________ Date ________

*Permission to duplicate this form is granted.

Welding Orientation
Unit 1

Teacher Supplement 1—An Abbreviated History of Arc Welding

Early welding history

In Germany, metals where joined by electric fusion as early as 1782. English, French, and Russian experiments in the 1800s established the principles of striking and maintaining an electric arc with controlled voltage, and the first arc welding process resulted from ongoing efforts.

Early 1900 events

The first patent was issued for a covered electrode and arc-welding methods were used to weld ship hulls and produce armaments during World War I.

Middle 1900 events

A new manufacturing process greatly reduced the cost of covered electrodes and arc welding applications expanded into the aircraft, manufacturing, and construction industries.

Later 1900 events

World War II inspired many advances in arc welding technology. Improvements in electrodes and improved applications of shielding gases brought high speed applications for the thousands of all-welded ships produced in World War II, in aircraft production, and in armaments.

Recent welding history

New arc welding processes such as GTAW and GMAW were developed to meet the special needs of industrial production and there were ongoing improvements and advances in electrode technology.

Modern welding history

Advances continued in electric arc welding and brought such processes as arc spot welding, atomic-hydrogen welding, electro-slag and electro-gas welding, plasma-arc welding and cutting, submerged arc welding, and yet other processes to answer special industry needs.

Welding Orientation
Unit 1

Teacher Supplement 2—Professional Organizations That Benefit Welders

Since welding is a metals and materials industry, the professional organizations that benefit welders do so by keeping pace not only with the world of welding, but changes, improvements, and trends in the many products associated with welders and welding. A few of those organizations are listed here for the purpose of providing references to assist with the variety of information that welding programs sometimes require.

Aluminum Association
900 19th Street, NW, Suite 300
Washington, DC 20006
202-862-5100

American National Standards Institute
11 West 42nd Street, 13 Floor
New York, NY 10036
212-642-4900

American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017
212-705-7722

National Safety Council
444 North Michigan Avenue
Chicago, IL 60611
800-621-7619 Ext. 1300

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096
412-776-4841

American Iron and Steel Institute
1101 17th Street, NW, 13th Floor
Washington, DC 20036
202-452-7100

American Petroleum Institute
1220 L Street, NW
Washington, DC 20005
202-682-8000

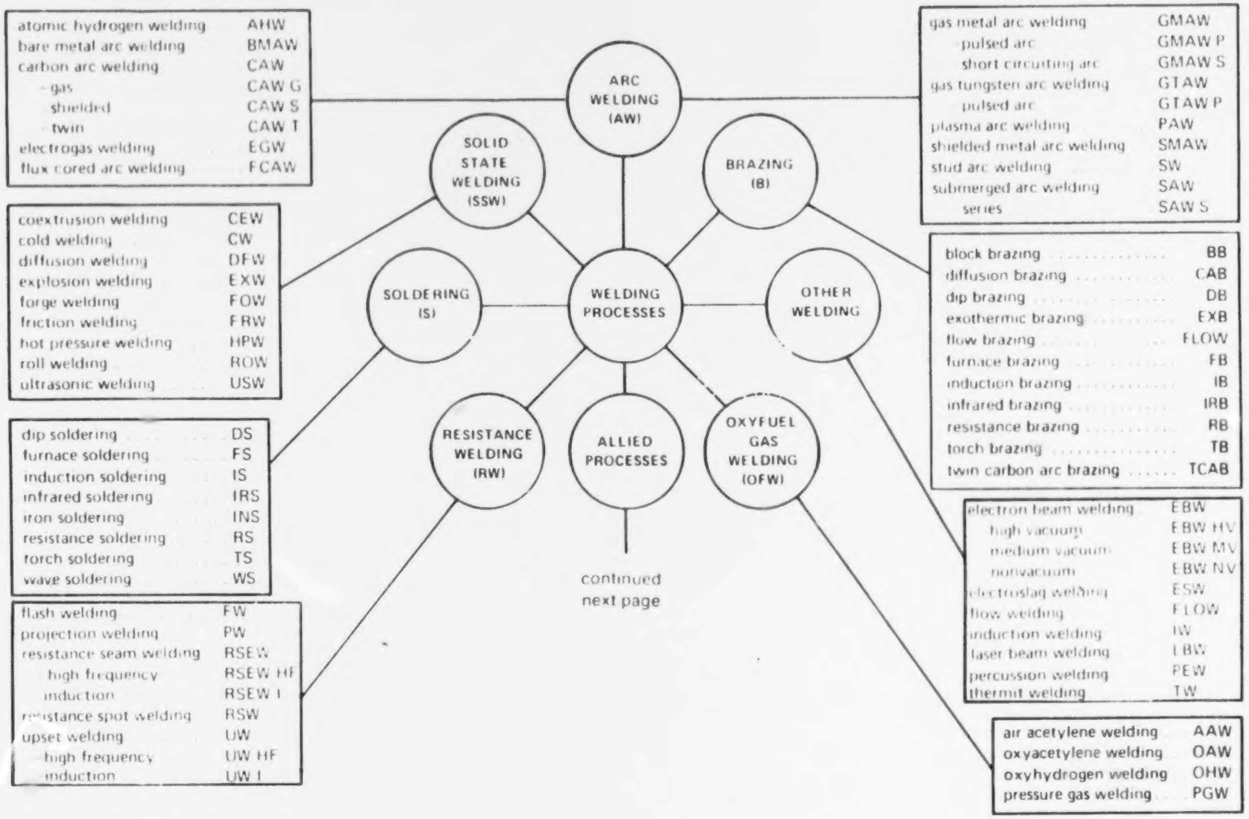
American Welding Society
550 LeJeune Road
P.O. Box 351040
Miami, FL 33135
800-443-9353

National Welding Supply Association
1900 Arch Street
Philadelphia, PA 19103
215-564-3484

American Society of Non-Destructive Testing
4153 Arlingate Plaza, Caller #28518
Columbus, OH 43228-0518

***Permission to duplicate this supplement is granted.**

Master Chart of Welding and Allied Processes



atomic hydrogen welding	AHW
bare metal arc welding	BMAW
carbon arc welding	CAW
gas	CAW G
shielded	CAW S
twin	CAW T
electrogas welding	EGW
flux cored arc welding	FCAW

gas metal arc welding	GMAW
pulsed arc	GMAW P
short circuiting arc	GMAW S
gas tungsten arc welding	GTAW
pulsed arc	GTAW P
plasma arc welding	PAW
shielded metal arc welding	SMAW
stud arc welding	SW
submerged arc welding	SAW
series	SAW S

coextrusion welding	CEW
cold welding	CW
diffusion welding	DFW
explosion welding	EXW
forge welding	FOW
friction welding	FRW
hot pressure welding	HPW
roll welding	ROW
ultrasonic welding	USW

block brazing	BB
diffusion brazing	CAB
dip brazing	DB
exothermic brazing	EXB
flow brazing	FLOW
furnace brazing	FB
induction brazing	IB
infrared brazing	IRB
resistance brazing	RB
torch brazing	TB
twin carbon arc brazing	TCAB

dip soldering	DS
furnace soldering	FS
induction soldering	IS
infrared soldering	IRS
iron soldering	INS
resistance soldering	RS
torch soldering	TS
wave soldering	WS

electron beam welding	EBW
high vacuum	EBW HV
medium vacuum	EBW MV
nonvacuum	EBW NV
electroslag welding	ESW
flow welding	FLOW
induction welding	IW
laser beam welding	LBW
percussion welding	PEW
thermit welding	TW

flash welding	FW
projection welding	PW
resistance seam welding	RSEW
high frequency	RSEW HF
induction	RSEW I
resistance spot welding	RSW
upset welding	UW
high frequency	UW HF
induction	UW I

air acetylene welding	AAW
oxyacetylene welding	OAW
oxyhydrogen welding	OHW
pressure gas welding	PGW

continued
next page

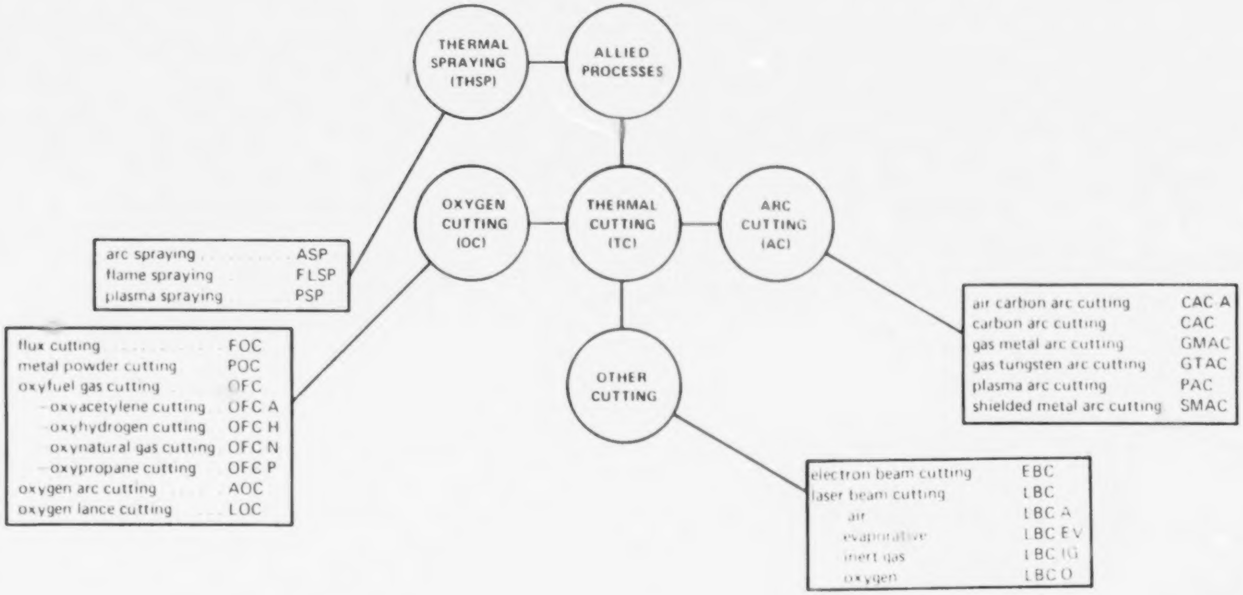
Courtesy American Welding Society

Fundamentals of Welding, Unit 1
Teacher Page 21

TM 1

Master Chart of Welding and Allied Processes

(Continued)



THERMAL SPRAYING (THSP)

ALLIED PROCESSES

OXYGEN CUTTING (OC)

THERMAL CUTTING (TC)

ARC CUTTING (AC)

OTHER CUTTING

arc spraying	ASP
flame spraying	FLSP
plasma spraying	PSP

flux cutting	FOC
metal powder cutting	POC
oxyfuel gas cutting	OFC
–oxyacetylene cutting	OFC A
–oxyhydrogen cutting	OFC H
–oxynatural gas cutting	OFC N
–oxypropane cutting	OFC P
oxygen arc cutting	AOC
oxygen lance cutting	LOC

air carbon arc cutting	CAC A
carbon arc cutting	CAC
gas metal arc cutting	GMAC
gas tungsten arc cutting	GTAC
plasma arc cutting	PAC
shielded metal arc cutting	SMAC

electron beam cutting	EBC
laser beam cutting	LBC
air	LBC A
evaporative	LBC EV
inert gas	LBC IG
oxygen	LBC O

Courtesy American Welding Society

Fundamentals of Welding, Unit 1
Teacher Page 23

TM 2

Welding Orientation
Unit 1

Information Sheet

1. **Terms and definitions**

   a. **Base metal** — The metal or alloy that is welded, brazed, soldered, or cut

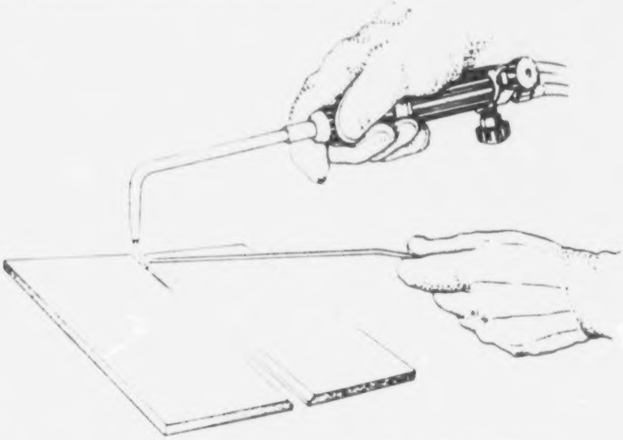
   b. **Coalescence** — The growing together or growth into one body of the materials being welded

   c. **Fusion welding** — The melting together of filler metal and base metal, or of base metal only, to produce a weld

   d. **Welding** — A joining process that produces coalescence of materials by heating to a melthing point, with or without the application of pressure and with or without the use of filler metal

2. **Welding processes and their applications**

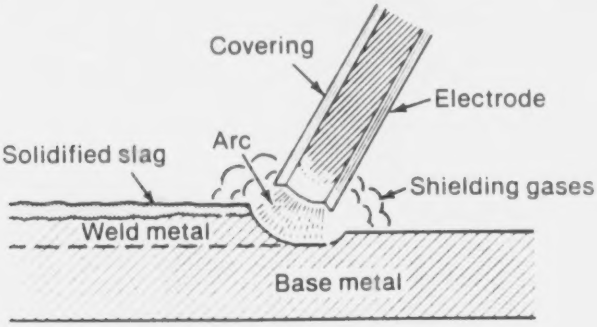
   a. Oxyfuel Gas Welding (OFW)—A group of welding processes that produces coalescence by heating materials with an oxyfuel gas flame or flames, with or without pressure, and with or without the use of filler material



Courtesy Union Carbide Corporation, Linde Division

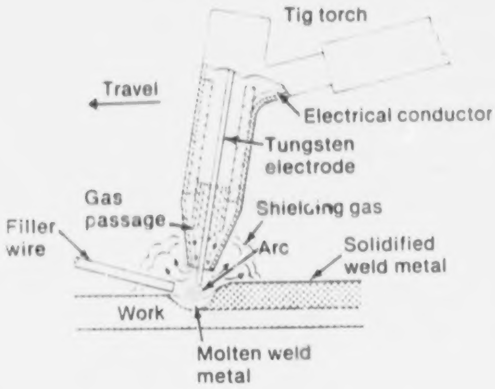
Information Sheet

b. Shielded Metal Arc Welding (SMAW)—An arc welding process that produces coalescence of materials by heating them with an arc between a covered electrode and a workpiece; shielding is obtained from decomposition of the electrode cover, pressure is not used, and filler metal is obtained from the electrode


Covering
Electrode
Arc
Solidified slag
Shielding gases
Weld metal
Base metal

Courtesy Lincoln Electric Company

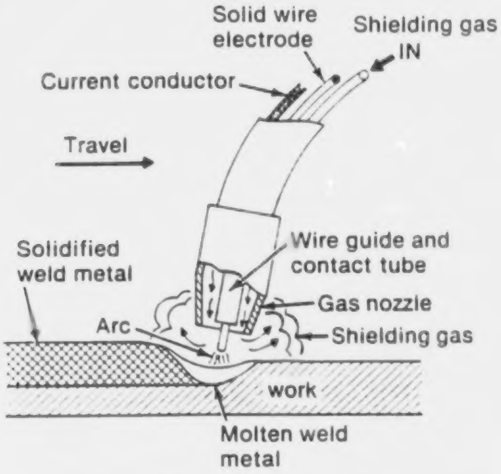
c. Gas Tungsten Arc Welding (GTAW)—An arc welding process that prodcues coalescence of materials by heating them with an arc between a nonconsumable tungsten electrode and a workpiece; shielding is obtained from a gas, and filler metal may or may not be used


Tig torch
Travel
Electrical conductor
Tungsten electrode
Gas passage
Shielding gas
Filler wire
Arc
Solidified weld metal
Work
Molten weld metal

Courtesy Lincoln Electric Company

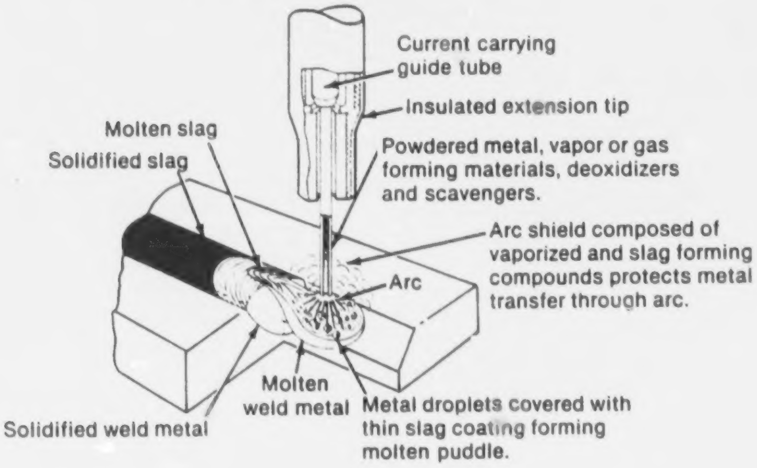
Information Sheet

d. Gas Metal Arc Welding (GMAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is obtained entirely from an externally supplied gas


Solid wire electrode
Shielding gas IN
Current conductor
Travel
Solidified weld metal
Wire guide and contact tube
Gas nozzle
Arc
Shielding gas
work
Molten weld metal

Courtesy Lincoln Electric Company

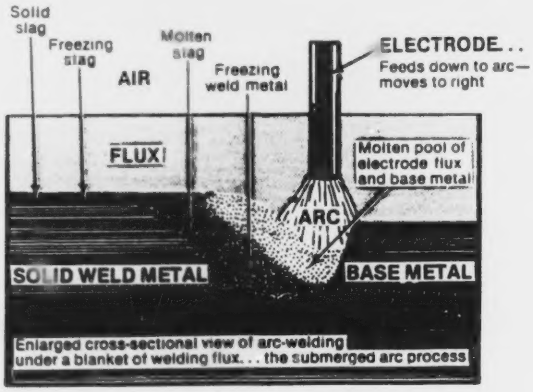
e. Flux-Cored Arc Welding (FCAW)—An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal electrode and a workpiece; shielding is provided by a flux contained within the tubular electrode, and additional shielding may or may not be obtained from an externally supplied gas or gas mixture


Current carrying guide tube
Insulated extension tip
Molten slag
Solidified slag
Powdered metal, vapor or gas forming materials, deoxidizers and scavengers.
Arc shield composed of vaporized and slag forming compounds protects metal transfer through arc.
Arc
Molten weld metal
Metal droplets covered with thin slag coating forming molten puddle.
Solidified weld metal

Courtesy Lincoln Electric Company

Information Sheet

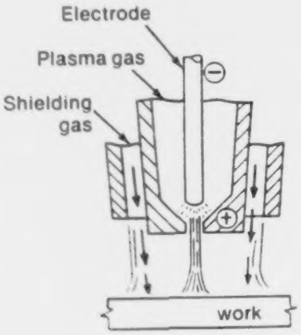
f. Submerged arc welding (SAW)—An arc welding process that produces coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and a workpiece; the arc and molten metal are shielded by a blanket of granular, fusible material on the workpiece; pressure is not used, and filler metal is obtained from the electrode or sometimes from a supplemental source


Solid slag
Freezing slag
AIR
Molten slag
Freezing weld metal
ELECTRODE. . .
Feeds down to arc—moves to right
FLUX!
Molten pool of electrode flux and base metal
ARC
SOLID WELD METAL
BASE METAL
Enlarged cross-sectional view of arc-welding under a blanket of welding flux. . . the submerged arc process

Courtesy Lincoln Electric Company

g. Plasma Arc Welding (PAW)—An arc welding process that produces coalescence of metals by heating them with a constricted arc between a nonconsumable electrode and a workpiece (transferred arc), or the electrode and a constricting nozzle (nontransferred arc)

h. In PAW, shielding is obtained from the hot, ionized gas issuing from the torch, and this may be supplemented with an auxiliary source of shielding gas; shielding gas may be an inert gas or a mixture of gases, and filler metal may or may not be used


Electrode
Plasma gas
Shielding gas
⊖
⊕
work

Courtesy Lincoln Electric Company

Information Sheet

3. Brazing and braze welding

a. Brazing is a group of welding processes that produces coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having a melting point above 840°F and below the melting point of the base metal.

b. In brazing processes, the filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

c. Braze welding is a welding process variation that uses a filler metal with a melting point above 840°F and below the melting point of the base metal.

d. Unlike brazing, in braze welding, the filler metal is not distributed in the joint by capillary action.

4. Cutting processes

a. Oxyfuel Gas Cutting (OFC)—A group of cutting processes used to sever metals by means of the chemcial reaction of oxygen with a base metal at elevated temperatures; the necessary temperature is maintained by means of gas flames obtained from the combustion of a specified fuel gas and oxygen

Note: The oxyfuel cutting processes include oxyacetylene, OFC-A; oxyhydrogen, OFC-H; oxynatural, OFC-N; oxypropane, OFC-P; and others.

b. Arc Cutting (AC)—A group of cutting processes that sever or remove metal by melting with the heat of the arc between an electrode and the workpiece.

Note: Some popular arc cutting processes are air carbon arc cutting (AAC), arc cutting (AC), and plasma arc cutting (PAC); and these processes are discussed in other texts of the MAVCC welding series.

5. Where welders work

a. In its latest report, the Bureau of Labor Statistics reported that 3 out of 4 welding jobs are held by welders and cutters, while welding machine operators hold about 1 out of 4.

b. About 6 out of 10 welding jobs are in plants that manufacture boilers, construction equipment, motor vehicles, machinery, ships, appliances, and other metal products.

Information Sheet

c. About 4 out of 10 welding jobs are with firms that construct bridges, large buildings, pipelines, other structures, or repair ships.

d. All welding machine operators work in manufacturing industries, primarily machinery, motor vehicles, and fabricated metal products.

6. What welders earn

a. The median earning for welders and welding machine operators was about $400 a week in the late 1980s.

Note: Figures are from the Bureau of Labor Statistics for the late 1980s.

b. Beginners and lesser paid welders averaged $225 a week, but welders in the top 10 percent income bracket earned over $600 a week.

c. Many welders work in situations where company benefits make the job more attractive, and over one-third of all welders belong to a union.

Note: Some of the unions that welders find attractive are the International Association of Machinists and Aerospace Workers; the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers; United Automobile, Aerospace and Agricultural Implement Workers of America; and the United Association of Journeyman and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada.

7. Job outlook for welders

a. Employment of welders and cutters in construction is expected to grow as fast as the average for all occupations through the year 2000.

b. In some areas, the need for welders will decline through the year 2000, but many job openings will arise because of the need to replace experienced workers who transfer or retire.

c. The areas that look best for good welding jobs are in construction and repair because these are areas that are difficult to automate.

d. Many jobs will be open in manufacturing, but they will be jobs in maintenance, repair, and other areas where the work cannot be automated.

Information Sheet

8. What it takes to become a good welder

a. Training for welding should start early in high school and include courses in shop math, mechanical drawing, print reading, physics, and chemistry.

b. Some welding machine operators can learn their jobs in a few days or weeks, but employers prefer applicants who have high school, vocational and/or post-secondary training in welding.

c. Welders and cutters need manual dexterity, good eyesight, and good eye-hand coordination.

d. Good welders should also be able to concentrate on detailed work for long periods, and be able to bend, stoop, and work in awkward positions.

9. Career opportunities for welders

a. The welding machine operator or robotic welder operator will probably take a specialized course to learn the equipment and work in a manufacturing facility that uses that equipment.

b. The combination welder will normally be found in plant maintenance or a repair shop, and because combination welders can do it all, they are often in demand.

c. The welder-fitter is something of a specialist and works in manufacturing jobs that require a knowledge of metallurgy and joint design in addition to welding skills.

d. The specialist welder will become highly skilled in one or two welding processes and work on special products or projects.

Example: The gas tungsten arc process on stainless steel is a popular process for making bright, shiny salad bars and other restaurant equipment, and is also used frequently with stainless steel applications in medical installations.

e. Welders who demonstrate leadership ability often advance to a supervisory position and may run a welding crew or supervise welders in a facility.

f. Other advanced jobs open to skilled welders include:

    (1) Welding inspector;
    (2) Welding tester;
    (3) Equipment salesperson;
    (4) Sales troubleshooter;
    (5) Welding instructor.

g. Welders who continue their education can advance to the level of welding engineer, metallurgist, or several other jobs where associate or advanced college degrees are required.

Information Sheet

10. Standards and their importance to the welding industry

a. In 1936, the Committee on Standard Qualification Procedures issued its first report to the American Welding Society; the report called for general qualification standards for procedures and performances of welders.

b. Today, standards guide many industrial producers, and standards affecting welding are produced by other groups who have welding minimums that must be met and procedures that must be followed.

Note: Standards include codes, specifications, recommended practices, classifications, methods, and guides.

Examples: The American Petroleum Institute sets standards for pipeline welding, the American Society of Mechanical Engineers, among others, sets standards for high pressure boilers, and the Aluminum Association sets standards for welding aluminum.

c. The American Welding Society has various committees who meet to update and change standards as needs require, and among these standards, three are important to all welders, including beginners:

(1) Standard for Welding Procedure and Performance Qualification
(2) Standards Symbols for Welding, Brazing, and Nondestructive Examination
(3) Standard Welding Terms and Definitions

Note: The standards for symbols and terms are not only AWS standards, they are also American National Standards adapted by the American National Standards Institute, ANSI.

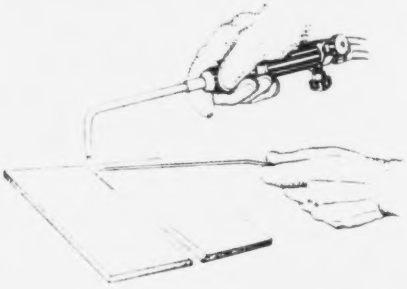
Welding Orientation
Unit 1

Assignment Sheet 1—Identify Welding Processes

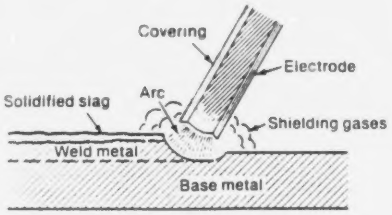
Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Number of correct process identifications	______

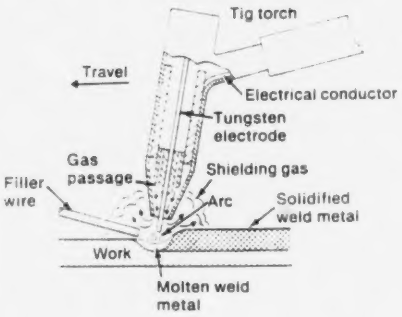
Directions: Examine the illustrations that follow. Insert the number of the process name beside the appropriate illustration.



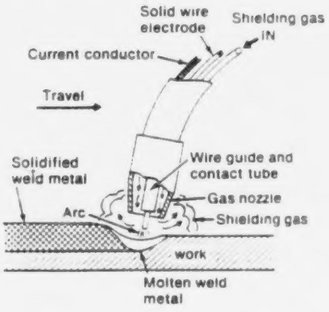
a. ______


Covering
Electrode
Arc
Solidified slag
Shielding gases
Weld metal
Base metal

b. ______


Tig torch
Travel
Electrical conductor
Tungsten electrode
Gas passage
Shielding gas
Filler wire
Arc
Solidified weld metal
Work
Molten weld metal

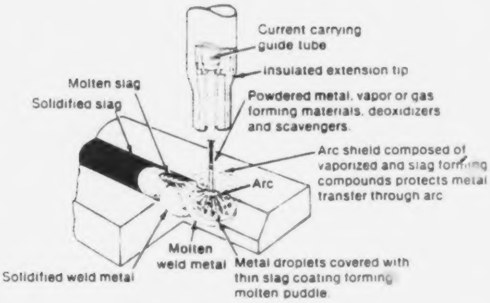
c. ______


Solid wire electrode
Shielding gas IN
Current conductor
Travel
Solidified weld metal
Wire guide and contact tube
Gas nozzle
Arc
Shielding gas
work
Molten weld metal

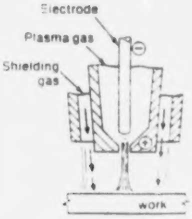
d. ______

1. Gas metal arc welding (GMAW)
2. Shielded metal arc welding (SMAW)
3. Oxyfuel gas welding (OFW)
4. Gas tungsten arc welding (GTAW)

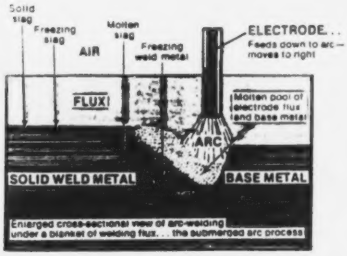
Assignment Sheet 1


Current carrying guide tube
Insulated extension tip
Molten slag
Solidified slag
Powdered metal, vapor or gas forming materials, deoxidizers and scavengers.
Arc shield composed of vaporized and slag forming compounds protects metal transfer through arc
Arc
Molten weld metal
Solidified weld metal
Metal droplets covered with thin slag coating forming molten puddle

e. ______


Electrode
Plasma gas
Shielding gas
work

f. ______


Solid slag
Freezing slag
AIR
Molten slag
Freezing weld metal
ELECTRODE...
Feeds down to arc — moves to right
FLUX
Molten pool of electrode flux and base metal
ARC
SOLID WELD METAL
BASE METAL
Enlarged cross-sectional view of arc-welding under a blanket of welding flux... the submerged arc process

g. ______

5. Submerged arc welding (SAW)
6. Plasma arc welding (PAW)
7. Flux cored arc welding (FCAW)

Welding Safety and First Aid
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to follow safety rules and guidelines for the welding workplace and select proper first aid procedures for workplace accidents. The student should demonstrate these competencies by completing the assignment sheets and by scoring 100 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding safety and first aid with their correct definitions.
2. Match safety color codes with their uses.
3. Match accident prevention signs with their colors and uses.
4. Match accident prevention tags with their colors and uses.
5. Complete statements about the ALWAYS rules for welding safety.
6. Complete statements about the NEVER rules for welding safety.
7. Select true statements about shop safety rules.
8. Complete statements about eye safety.
9. Complete statements about good housekeeping rules.
10. Match factors contributing to back injuries with their causes.
11. Arrange in order the steps in safe lifting.
12. Select conditions that indicate OSHA requirements for employers.
13. Select conditions that indicate OSHA requirements for employees.

Objective Sheet

14. List rules for personal safety.
15. Select true statements about personal physical and hygiene requirements.
16. Match types of fires with their classifications.
17. Select true statements about fire safety rules.
18. Complete statements about guidelines for oxygen safety.
19. Select true statements about guidelines for acetylene safety.
20. Select true statements about other fuel gas safety.
21. Complete statements about guidelines for shielding gas safety.
22. Solve problems about rules for handling gas cylinders safely.
23. Select true statements about guidelines for electrical safety.
24. Select true statements about ways to recognize shock.
25. Arrange in order the steps in treating shock.
26. Select true statements about steps in administering first aid to a victim of electrical shock.
27. Select true statements about first aid for minor cuts.
28. Select true statements about first aid for puncture wounds.
29. Select true statements about first aid for slivers and splinters.
30. Select true statements about first aid for thermal burns.
31. Select true statements about first aid for chemical burns.
32. Arrange in order the steps in controlling bleeding.
33. Solve problems about first aid for eye injury.
34. Complete statements about guidelines for general first aid emergencies.
35. Complete a student safety pledge. (Assignment Sheet 1)
36. Respond to first aid requirements. (Assignment Sheet 2)

Welding Safety and First Aid
Unit 2

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Golden Rules for Welding (Objective 7)
   TM 2—Eye and Face Protection (Objective 8)
   TM 3—OSHA Poster #2203 (Objectives 12 and 13)
   TM 4—Fire Safety (Objectives 16 and 17)
   TM 5—Standard Accident Form (Objective 34)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheets. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skills have been adapted by MAVCC.

1. Use Objectives 10 and 11 to impress upon students that back problems constitute the most common claims in workers compensation cases. Check with your school or local library to see if compensation statistics are available for your state. Use them to reinforce the fact that national statistics do apply to local situations.

2. Take advantage of National Fire Prevention Week activities to review fire safety information in Objectives 16 and 17. Have qualified people demonstrate the proper use of the fire extinguishers in your welding area. Take advantage of the demonstration to point out escape routes in the event of a fire and reassembly points outside the building

3. Coordinate teaching the first aid objectives in this unit with the school nurse, local Red Cross, or the Emergency Medical System that serves your area. Students should receive proper training in rescue breathing. Students should be encouraged to take a formal course in cardiopulmonary resuscitation, CPR. Students should also be cautioned not to attempt CPR unless they have had training in the procedure.

4. Invite the school nurse to talk to students about shock and steps in treating shock. This information is treated in Objectives 24 and 25, but it needs reinforcement by demonstration from a qualified person. Skill area: **listening**.

Suggested Activities

Resources Used in Developing This Unit

1. National Fire Protection Association. *Fire Protection Handbook, Fifteenth Edition.* Quincy, MA: National Fire Protection Association, 1981.
2. *OSHA Safety and Health Standards (29 CFR 1910), Revised.* Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration, 1981.
3. *American Red Cross: Multimedia Standard First Aid.* The American National Red Cross, 1987.
4. *Instructor's Manual for Basic Life Support.* Dallas, TX: American Heart Association, 1990.
5. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology.* Miami, FL: American Welding Society, 1987.
6. O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes.* Miami, FL: American Welding Society, 1991.
7. Fortney, Clarence and Mike Gregory. *Introduction to Welding.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

Suggested Supplemental Resources

1. *The Welding Handbook, Eighth Edition, Vol. 1, Welding Technology* is a substantial source for welding safety information in a variety of categories. Vol. 2, *Welding Processes* also contains vital safety information. Both texts are highly recommended references that every welding program should have available for both reference and instruction. The books are available with an education discount from:

   Order Department
   American Welding Society
   550 Northwest LeJeune Road
   P.O. Box 351040
   Miami, FL 33135
   800-334-9353

2. *American Red Cross: Multimedia Standard First Aid* is a valuable resource for first aid procedures, and especially for the cuts and burns that welders are subject to. This text is a workbook which has a video supplement to make it a formal course in first aid. Speak with your school administrators about adopting the materials for a formal program at your school.

Suggested Activities

3. CGA-1 "Safe Handling and Storage of Compressed Gases" is available as a slide/audiocassette presentation or in a ½" videotape format. The program is available from:

   Compressed Gas Association
   1235 Jefferson Davis Highway
   Arlington, VA 22202
   703-979-0900

   Note: Other programs for handling gases and cylinders safely are referenced in *Oxyacetylene Welding and Cutting*, also published by MAVCC. Check the Suggested Activities in Unit 1 of *OAW* for several other safety programs.

Welding Safety and First Aid
Unit 2

Answers to Assignment Sheets

Assignment Sheet 1—Evaluated according to written criteria

Assignment Sheet 2

1. a. Clean the cut again.
   b. Cover with a dry sterile dressing.

2. a. Nothing; deeply embedded splinters should not be removed.
   b. Notify your supervisor or instructor.

3. a. The student is probably suffering from shock.
   b. Treat for shock.

4. a. No.
   b. Apply another compress over the first one.

5. a. Apply a sterile dressing.
   b. Bandage loosely and get medical help immediately.

6. a. Seek the most immediate medical attention.
   b. Seek the most immediate medical attention.

7. a. Make written notes about the accident; name of victim, time, place, cause or nature of the accident, and any first aid that was administered.
   b. Report the accident to your instructor or supervisor.

Welding Safety and First Aid
Unit 2

Answers to Written Test

1. a. 4
   b. 5
   c. 2
   d. 6
   e. 3
   f. 7
   g. 1
   h. 9
   i. 8
   j. 10

2. a. 6
   b. 5
   c. 4
   d. 2
   e. 1
   f. 3
   g. 8
   h. 7

3. a. 2
   b. 1
   c. 3

4. a. 4
   b. 3
   c. 1
   d. 2

5. a. Eye protection
   b. Clean
   c. Good condition
   d. Safe to work in
   e. Dangerous and potentially lethal
   f. Three or four
   g. Look out for

6. a. Safety glasses
   b. Flammable or explosive materials
   c. Oil
   d. An electrode holder
   e. Ungrounded
   f. On concrete
   g. On wet or damp floors
   h. Purged
   i. Ground
   j. Horseplay of any kind

7. a, b, c, d, f, g, h

Answers to Written Test

8. a. Safety glasses
b. Safety glasses and a face shield
c. Contact lenses
d. Chipped, cracked, or damaged
e. Plastic-coated
f. So don't mix lenses
g. All welding and cutting activity

9. a. Cleaning
b. Proper
c. Designated areas
d. Work benches
e. Slippery
f. Exits
g. Combustible
h. Oily
i. Brooms, brushes

10. a. 2
b. 5
c. 6
d. 3
e. 7
f. 1
g. 4

11. a. 1
b. 2
c. 7
d. 5
e. 3
f. 7
g. 6
h. 4

12. a. 2
b. 3

13. a. 1
b. 3

14. a. Greasy
b. Rotating
c. Rotating
d. Wire frames
e. Safe
f. Butane or propane

15. b, c, d

16. a. 2
b. 4
c. 1
d. 3

Answers to Written Test

17. b, c, d, e, f, h, i

18.
    a. Under pressure
    b. Highly combustible materials
    c. Used and stored
    d. Refrigerated
    e. Liquid
    f. Temperature rises

19. a, b, e

20. a, b, c

21.
    a. An upright
    b. Carbon dioxide and nitrogen
    c. Can displace oxygen in the air

22.
    a. 2
    b. 3
    c. 1
    d. 2

23. b, d, f, g, h, i, j, k, l, m

24. a, b, c, f

25.
    a. 2
    b. 5
    c. 4
    d. 3
    e. 1
    f. 6

26. a, b, e

27. a, b, c

28. b, c, d

29. a, c, d

30. a, b

31. a, b, c, d, e

Answers to Written Test

32. a. 7
    b. 4
    c. 1
    d. 6
    e. 2
    f. 5
    g. 3

33. a. 2
    b. 2
    c. 1

34. a. First aid
    b. Have a reason
    c. EMS
    d. Everything possible
    e. Accurate written
    f. Medical facility
    g. Minor
    h. Complete

Welding Safety and First Aid
Unit 2

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

______a. State or condition of being safe; freedom from danger, risk, or injury

______b. Any suddenly occurring, unintentional event which causes personal injury or property damage

______c. immediate, temporary care given the victim of an accident or sudden illness until the service of a doctor can be obtained

______d. The Occupational Safety and Health Administration; federal legislation designed to insure safe and sanitary working conditions for employees

______e. Materials or liquids that catch fire easily

______f. The science of good health and its maintenance, including sanitary practices and cleanliness

______g. An acute, infectious disease that usually enters the body through cuts or wounds; characterized by spasmodic contractions or rigidity of some voluntary muscles and frequently referred to as lockjaw

______h. A bandage or strap twisted around a limb to compress the flow of blood through arteries and check severe bleeding; previously a recommended first aid procedure, but now recommended of only for life-threatening situations

1. Tetanus
2. First aid
3. Combustibles
4. Safety
5. Accident
6. OSHA
7. Hygiene

Written Test

______i. A burn on the exterior membrane of the eye caused by exposing the naked eye to the ultra-violet and infra-red rays in the flash of an electric arc, or the exposure of improperly covered body areas to the flash of an electric arc

______j. Skin tissue damage caused by exposure to intense cold

8. Arc burn
9. Tourniquet
10. Frostbite

2. Match safety color codes with their uses.

______a. (1) Applied to nonhazardous parts of machine and equipment surfaces, like nameplates and bearing surfaces

(2) Designates safe areas of equipment, and is also used to show location of safety equipment and first-aid materials

______b. (1) Applied to operating levers, wheels handles, and hazardous parts that may cause stumbling, falling, snagging, or tripping

(2) Designates caution

______c. (1) Applied to electrical switches, interior surfaces of doors, fuses and electrical power boxes, and movable guards and parts

(2) Indicates dangerous parts of equipment which may cut, crush, shock, or otherwise physically injure someone

______d. (1) Applied to buttons or levers of electrical switches used for stopping machinery, and to all equipment, such as gasoline cans, which are fire hazards

(2) Designates fire hazards and fire-fighting equipment

1. Safety blue
2. Safety red
3. Safety ivory
4. Safety orange

Written Test

_______e. (1) Used to identify equipment which is being repaired or is defective and should not be operated

(2) Designates "out of order" or "defective"

_______f. (1) Applied to label edges, vise jaws, and edges of tool rests where extra light reflection is important

(2) Used to show tool and equipment moving edges more clearly

_______g. (1) Applied to area where radiation is a factor or danger

(2) Designates radiation hazards

_______h. (1) Applied to floors for safety lanes and location of housekeeping supplies

(2) The single or combination use of these colors are used to identify traffic flow and housekeeping zones

5. Safety yellow
6. Safety green
7. Safety black, safety white, and safety yellow
8. Safety black on safety yellow

3. Match accident prevention signs with their colors and uses.

_______a. (1) Used where an immediate hazard exists

(2) Colors are red, black, and white

_______b. (1) Used to warn against potential hazards or to caution against unsafe practices

(2) Colors are yellow and black

_______c. (1) Used where there is a need for general instruction and suggestions relative to safety measures

(2) Colors are white, green, and black

1. Caution signs
2. Danger signs
3. Safety instruction signs

Written Test

4. Match accident prevention tags with their colors and uses.

______a. (1) Are placed at the starting mechanism on machines which would be hazardous should the equipment be energized
  (2) Colors are red, white, or gray

______b. (1) Are placed only where an immediate hazard exists
  (2) Colors are red, black, and white

______c. (1) Are used to warn against potential hazards or to caution against unsafe practices
  (2) Colors are yellow and black

______d. (1) Are used to identify pieces of equipment that are out of order
  (2) Colors are blue and white

1. Caution tags
2. Out of order tags
3. Danger tags
4. Do not start tags

5. Complete statements about the ALWAYS rules for welding safety. Circle the information that best completes each statements.

   a. Always wear suitable protective clothing and (**eye protection**) (**ear plugs**).

   b. Always keep a safe, (**open**) (**clean**) work area.

   c. Always keep welding equipment in (**good condition**) (**an out-of-the-way place**).

   d. Always check welding areas to make sure they're (**safe to work in**) (**well lighted**).

   e. Always respect gas cylinders as (**dangerous and potentially lethal**) (**expensive and easy to damage**).

   f. Always make sure ventilation provides (**one to two**) (**three to four**) complete changes of air per hour.

   g. Always (**trust**) (**look out for**) fellow students and coworkers.

Written Test

6. Complete statements about the NEVER rules for welding safety. Circle the information that best completes each statement.

   a. Never enter the welding shop without wearing (**safety glasses**) (**helmet and gloves**).

   b. Never weld, cut, or grind near (**fellow workers**) (**flammable or explosive materials**).

   c. Never use (**leak detector**) (**oil**) on gas cylinders, regulators, connections, or hoses.

   d. Never permit (**an electrode holder**) (**bare hands**) to come in contact with a welding machine or a gas cylinder.

   e. Never operate (**old**) (**ungrounded**) equipment.

   f. Never cut or weld directly (**on concrete**) (**against cast iron**).

   g. Never arc weld or operate electrically powered equipment while standing (**on wet or damp floors**) (**in a poorly lighted area**).

   h. Never cut into barrels, drums, or any container that has not been (**purged**) (**opened**).

   i. Never (**hang**) (**ground**) electrical equipment to a building member or a piece of equipment attached to or part of a building.

   j. Never engage in (**horseplay of any kind**) (**unsupervised welding**).

7. Select true statements about shop safety rules. Place an "X" beside each true statement.

   _______a. Keep all hand tools sharp, clean, and in safe working order.

   _______b. Report any defective tools, machines, or other equipment to the instructor.

   _______c. Keep all guards and safety devices securely in place.

   _______d. Operate a hazardous machine only after receiving instruction on how to operate the machine safely.

   _______e. Report all accidents to the instructor if they are severe enough.

   _______f. Turn off the power before leaving a machine tool.

   _______g. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool.

   _______h. Disconnect the power from machine tools before performing the maintenance tasks of oiling or cleaning.

Written Test

8. Complete statements about eye safety. Circle the information that best completes each statement.

   a. Wear (**safety glasses**) (**steel-toed shoes**) at all times in the welding shop.

   b. Wear (**safety glasses and a face shield**) (**a face shield**) when grinding, chipping, cutting, or shaping metal with any kind of power tool.

   c. If you wear (**glasses**) (**contact lenses**), check with your doctor to see if the type of lens you wear requires any special precautions in the work environment.

   d. Select proper lens shade for the welding or cutting activity and make sure the lens is not (**chipped, cracked, or damaged**) (**too dark**).

   e. Do not wear (**amber-colored**) (**plastic-coated**) lenses for welding or cutting.

   f. Remember that lens shade numbers are not additive, in other words, a #8 and a #6 lens will not give the same density as a #14 lens, (**so don't mix lenses**) (**so mix two darker shades**).

   g. Wear welding goggles or a welding hood with the proper lens shade for (**all welding and cutting activity**) (**all shop activity**).

9. Complete statements about good housekeeping rules. Circle the information that best completes each statement.

   a. Arrange machinery and equipment to permit safe, efficient work practices and ease in (**cleaning**) (**operation**).

   b. Store materials and supplies in (**locked**) (**proper**) places.

   c. Store tools and accessories safely in cabinets, on racks, or other (**designated areas**) (**storage bins**).

   d. Keep working areas and (**aisles**) (**work benches**) clear and free of debris and other hazards.

   e. Keep floors clean and free from obstructions and (**slippery substances**) (**water**).

   f. Keep aisles, traffic areas, and (**exits**) (**work benches**) free of materials or debris.

   g. Dispose of (**combustible**) (**scrap**) materials properly or store them in approved containers.

   h. Store (**shop**) (**oily**) rags in self-closing or spring-lid metal containers.

   i. Keep sufficient (**brooms, brushes,**) (**tools**) and other housekeeping equipment readily available.

Written Test

10. Match factors contributing to back injuries with their causes.

______a. This usually results from overestimating your physical abilities and trying to lift more weight than you can handle, and sometimes it results from trying to be macho in front of fellow workers.

______b. This usually results from moving an object that may be within your weight capacity, but too long, high, or wide to lift safely.

______c. This usually results from moving an object that may be within your weight capacity, but has a cylindrical or other odd shape that makes safe lifting difficult.

______d. This usually results from stacking materials so high that vision is limited and items in the pathway can't be seen.

______e. This usually results from twisting or turning into an awkward position when lifting.

______f. This results in strain caused by not storing heavy objects at least 12" off the floor.

______g. This usually results from carelessly using chairs or boxes to reach from instead of safely using a ladder.

1. Improper storage
2. Weight
3. Obstructions
4. Improper reaching
5. Size
6. Shape
7. Improper position

11. Arrange in order the steps in safe lifting. Place a "1" beside the first step, a "2" beside the second step, and continue in order.

______a. Approach the load, size up its weight, size, and shape and consider your physical ability to handle it.

______b. Place your feet close to the object to be lifted and keep your feet 8 to 12 inches apart for good balance.

______c. Se the load down by using leg and back muscles together, slowly lower the load by bending your knees, and release your grip only after the load is securely positioned.

Written Test

_______d. Lift the load into carrying position, making no turning or twisting movements until the lift is completed.

_______e. Bend your knees to a degree that it is comfortable, get a good hand hold, then use both leg and back muscles to begin the lift.

_______f. When lifting or carrying with another worker, make sure the load is equally distributed, and carry long objects at the same level and on the same side of the body.

_______g. Turn your body with changes of foot position while you visually check your path of travel to make sure it is clear.

_______h. Lift the load straight up, smoothly and evenly, while you push with your legs and keep the load as close as possible to your body.

12. Select conditions that indicate OSHA requirements for employers. Circle the number of the information that best indicates an OSHA requirement.

    a. A new worker in the shop is looking for signs that the company is in compliance with OSHA requirements. One of the first things to look for would be:

        (1) A clean workplace
        (2) OSHA poster #2203 posted in a prominent place
        (3) OSHA literature in the break room

    b. A worker wonders about the safety record of an employer. The worker should look for:

        (1) Safety information in the company's annual report
        (2) Statistics from the state labor organization
        (3) An annual summary of work-related accidents posted no later than the end of February

13. Select conditions that indicate OSHA requirements for employees. Circle the number of the information that best indicates an OSHA requirement.

    a. An employee finds a hazardous condition on the job. The employee should immediately:

        (1) Report the condition to a supervisor
        (2) Talk it over with fellow employees
        (3) Write to OSHA immediately

    b. An employee who has reported a hazardous condition in the workplace finds that the employer has done nothing to correct the condition after several weeks. The employee should:

        (1) Report the condition to a supervisor again
        (2) Call a state safety office with the information
        (3) In a responsible manner, report the condition to the nearest OSHA office

Written Test

14. List rules for personal safety. Circle the information that best completes each of the following statements.

    a. Wear shop clothing appropriate to the instructional activity being performed, and do not wear (**greasy**) (**worn**) clothing.

    b. Confine long hair before operating (**rotating**) (**welding**) equipment.

    c. Remove ties when working around machine tools or (**rotating**) (**grinding**) equipment.

    d. Remove rings and other jewelry when working in the shop, and avoid wearing safety glasses that have (**wire frames**) (**plastic lenses**).

    e. Conduct yourself in a manner conducive to (**safe**) (**normal**) shop practices.

    f. Do not smoke in restricted areas, and do not carry a (**butane or propane**) (**cigarette**) lighter in your pocket around any welding or cutting activity.

15. Select true statements about personal physical and hygiene requirements. Place an "X" beside each true statement.

    ______a. Take a bath or shower weekly.

    ______b. Stay in good physical condition because this also promotes good psychological health.

    ______c. Do not drink alcoholic beverages or use drugs on the job, and don't show up for work with a hangover.

    ______d. Pay attention all the time because the majority of accidents happen to beginners in their first few months of work.

16. Match types of fires with their classifications.

    ______a. Fires that occur in ordinary combustible materials

    ______b. Fires that occur in flammable liquids

    ______c. Fires that occur in electrical and electronic equipment

    ______d. Fires that occur in combustible metals

    1. Class C
    2. Class A
    3. Class D
    4. Class B

Written Test

17. Select true statements about fire safety rules. Place an "X" beside each true statement.

_______a. Report weekly any items you feel could be a potential fire hazard.

_______b. Know the location and the proper operation of fire extinguishers and make sure they have been recently checked.

_______c. Know where the nearest telephone is and make sure the number of the nearest fire department is listed on the phone.

_______d. Know the procedure for evacuating the building and the location of all fire exits in case one or more exits may be blocked.

_______e. Smoke only at authorized times and in authorized areas and make sure cigarette butts are completely extinguished and properly discarded.

_______f. Examine materials and equipment around the workplace to determine what types of fires might occur, then make sure available fire extinguishers are correct for the classes of fires that might occur.

_______g. Isolate combustible materials in one area of the building.

_______h. Dispose of rubbish regularly.

_______i. Conduct fire drills at regular intervals to make sure the alarm can be heard over shop noises, and that everyone knows evacuation routes, exits, and assembly points.

18. Complete statements about guidelines for oxygen safety. Circle the information that best completes each of the following statements.

a. Since oxygen (**in storage**) (**under pressure**) may react violently in the presence of oil or grease, all oxygen fittings and equipment should be kept free of oil and grease.

b. Oxygen cylinders should never be stored near (**highly combustible materials**) (**any other fuels**) such as acetylene cylinders.

c. Oxygen should be (**used and stored**) (**stored**) with the valve end up.

d. (**Liquid**) (**Refrigerated**) oxygen cylinders have a double wall construction to help maintain a vacuum, and such cylinders should be handled with extreme care.

e. Avoid skin contact with (**liquid**) (**pressurized**) oxygen because its extremely low temperature can cause frostbite.

f. Oxygen cylinders should be protected against excessive (**cold**) (**temperature rises**).

Written Test

19. Select true statements about guidelines for acetylene safety. Place an "X" beside each true statement.

_______a. Because acetylene burns readily, acetylene cylinders should be kept safely away from open flames.

_______b. Acetylene cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

_______c. Never withdraw acetylene from a cylinder at pressure over 10 psi.

_______d. Never use acetylene from a cylinder that is lying on its side because acetone withdrawn with the acetylene could explode.

_______e. Acetylene cylinders should be protected against excessive temperature rises.

20. Select true statements about guidelines for other fuel gas safety. Place an "X" beside each true statement.

_______a. Propane and MPS cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

_______b. Both propane and MPS cylinders should be used and stored in an upright position.

_______c. Natural gas in cylinders should be handled with the same precaution as other fuel gas cylinders.

_______d. Whether used from a cylinder or from a piped-in supply, natural gas should be used just like other fuel gases.

21. Complete statements about guidelines for shielding gas safety. Circle the information that best completes each of the following statements.

a. In all cases, shielding gases should be used and stored in (**a horizontal**) (**an upright**) position.

b. Avoid skin exposure to (**carbon dioxide and nitrogen**) (**carbon dioxide and helium**) because both gases are cold enough to cause frostbite.

c. Because they (**are potentially explosive**) (**can displace oxygen in the air**), some nonflammable shielding gases such as argon, nitrogen, carbon dioxide, and helium should be stored in well ventilated areas.

Written Test

22. Solve problems about rules for handling gas cylinders safely. Circle the number of the information that provides the best solution to each of the following problems.

    a. A coworker is attempting to remove an oxygen cylinder fitting with a greasy wrench.

        (1) Never use a wrench on an oxygen fitting.
        (2) Never use oil or grease on an oxygen fitting.
        (3) Let your instructor remove the fitting.

    b. A coworker places an empty cylinder in the proper storage area, but fails to chain the cylinder in place.

        (1) Since the cylinder is empty, it does not need to be chained in place.
        (2) If the cylinder is safely away from the acetylene supply, it is safe.
        (3) Even empty cylinders should be chained.

    c. A coworker starts to roll an argon cylinder across the floor to get it out of the way. The cylinder still has a regulator attached to it.

        (1) Never transport a cylinder with the regulator attached, and never roll a cylinder horizontally across the floor.
        (2) Moving the cylinder a short distance poses no problem.
        (3) The regulator should be removed before the cylinder is rolled across the floor.

    d. You notice that a cylinder valve is not working properly.

        (1) Turn the gas off and replace the valve immediately.
        (2) Report the bad valve to your instructor immediately.
        (3) Tag the valve with the proper label and leave it for the gas delivery person to take care of.

23. Select true statements about guidelines for electrical safety. Place an "X" beside each true statement.

______a. Operate electrical equipment when you feel you know how.

______b. Do to touch live electrical parts or electrodes with your bare hands or exposed skin.

______c. Operate electrical parts with wet gloves or wet clothing only when you have to.

______d. Never touch an electrode to a grounded surface for these surfaces will become electrically live.

Written Test

_______e. Operate equipment beyond its rated capacity only in emergencies.

_______f. Know cable loads and do not use welding cables at currents in excess of their capacity.

_______g. Replace worn or bare cables to prevent electrical shock or damage to equipment.

_______h. Make sure all cable connections are tight, because loose connections could cause overheating of cables and electrical terminals.

_______i. When not in use, never place an electrode holder in contact with a grounded metal surface because it could short circuit the welding machine.

_______j. Machines must be installed according to national and local electrical codes.

_______k. Do not adjust or repair any electrical equipment until all power has been disconnected or the electrical breaker has been turned off.

_______l. Know where all emergency shut down switches are located.

_______m. All electrical equipment and tools should be properly grounded to prevent injury to the operator.

24. Select true statements about ways to recognize shock. Place an "X" beside each true statement.

_______a. Skin is pale or bluish.

_______b. Skin may be moist and clammy, even cold to the touch.

_______c. Victim feels weak.

_______d. Pulse is slow and weak.

_______e. Breathing rate is slow and irregular.

_______f. Victim may be confused or incoherent.

Written Test

25. Arrange in order the steps in treating shock. Place a "1" beside the first step, a "2" beside the second step, and list other steps in order.

______a. DO NOT DELAY immediate first aid treatment; it can be life saving.

______b. Cover the victim to retain body heat, but do not make the victim sweat.

______c. Keep the victim lying down with feet slightly elevated.

______d. Eliminate the causes of shock, control bleeding, or administer artificial respiration if the victim is not breathing.

______e. Notify your supervisor or instructor IMMEDIATELY.

______f. Give no liquids or food to the victim.

26. Select true statements about steps in administering first aid to a victim of electrical shock. Place an "X" beside each true statement.

Note: For a statement to be true, all parts of the statement must be true.

______a. Safely remove the victim from contact with the source of electricity using the following procedure:

(1) Turn off the electricity by means of a switch or circuit breaker or cut cables or wires by means of a wood-handled axe or insulated cutters, if available.
(2) Use a dry stick, rope, leather belt, coat, blanket, or any other nonconductor of electricity to separate the victim from the electrical circuit.

______b. Call for assistance:

(1) Others in the area may be more knowledgeable than you about treating the victim.
(2) Another person can call for professional medical help while you administer first aid.

______c. Check victim's breathing and heartbeat:

(1) If a pulse is detectable, but breathing has stopped, administer mouth-to-mouth resuscitation for at least five minutes.
(2) If the heartbeat has stopped, administer cardiopulmonary resuscitation, even if you are not sure of the proper technique.
(3) If both heartbeat and breathing have stopped, alternate between cardiopulmonary resuscitation and mouth-to-mouth resuscitation, but only if you have been trained in this technique.

______d. Administer first aid for shock and burns as necessary:

  (1) Use blankets or coats to help keep the victim as warm and comfortable as possible while waiting for help.
  (2) Leave the victim's legs slightly below head level to help prevent shock.
  (3) If the victim has suffered burns, cover your mouth and nostrils with gauze or a clean handkerchief to prevent breathing germs on the victim while treating the burns.
  (4) Wrap the burned area firmly with sterile gauze or clean linen or towels.

______e. Always continue treatment within your ability until medical help arrives.

27. Select true statements about first aid for minor cuts. Place an "X" beside each true statement.

______a. Clean the cut with mild soap and water, rinse thoroughly with water, and clean again as required.

______b. Cover the cut with a dry, sterile dressing.

______c. Notify your supervisor or instructor.

______d. There should be no risk of tetanus from a minor cut.

28. Select true statements about first aid for puncture wounds. Place an "X" beside each true statement.

______a. Puncture wounds through the skin need prompt medical attention to avoid bleeding.

______b. Clean the wound with soap and water, rinse thoroughly with water, clean again as required, and cover with a dry sterile dressing.

______c. Notify your supervisor or instructor.

______d. Always consider tetanus as a potential hazard.

29. Select true statements about first aid of slivers and splinters. Place an "X" beside each true statement.

______a. Deep penetration through the skin by slivers and splinters always carries the risk of infection and should be treated as such.

______b. Do remove deeply imbedded splinters as quickly as possible.

______c. Notify your supervisor or instructor.

______d. Always consider tetanus as a potential hazard.

Written Test

30. Select true statements about first aid for thermal burns. Place an "X" beside each true statement.

_______a. Give shock treatment to the victim immediately.

_______b. Remove clothing from the area of the burn, but do not remove material adhering to the burn area.

_______c. Apply a thick, dry sterile dressing and bandage loosely.

_______d. If a sterile dressing is not available use a close-woven, white, clean cloth and bandage loosely.

31. Select true statements about first aid for chemical burns. Place an "X" beside each true statement.

_______a. Give shock treatment to the victim immediately.

_______b. Immediately wash off the chemical with large quantities of running water.

_______c. Cut off clothing from the affected area.

_______d. Apply a thick, dry sterile dressing and bandage snugly to exclude air.

_______e. If a sterile dressing is not available, use a close-woven, white, clean cloth and bandage snugly.

32. Arrange in order the steps in controlling bleeding. Place a "1" beside the first step, a "2" beside the second step, and list other steps in order.

_______a. If there is a sever life-threatening hemorrhage, AND ONLY AS A LAST RESORT, APPLY A TOURNIQUET.

_______b. If blood soaks through the first compress, place another compress on it but do not remove the first compress.

_______c. Place a compress of sterile gauze or the cleanest available material directly over the bleeding area.

_______d. Treat the victim for shock.

_______e. Press firmly with your fingers or the palm of one hand.

_______f. Secure the compress or compresses with a pressure bandage.

_______g. Elevate the bleeding parts above the heart level unless there is evidence of a fracture.

Written Test

33. Solve problems about first aid for eye injury. Circle the number of the information that provides the best solution to each of the following problems.

a. You're giving first aid to a coworker who complains of something in an eye. You have the coworker wink several times, but tears produced by winking do not remove the object. You should now:

(1) Get your coworker to a doctor as soon as possible.
(2) Have the coworker close the eye, put a piece of moist cotton over the eyelid, place a bandage over the cotton, and then get your coworker to a doctor as soon as possible.
(3) Take your coworker to an eye wash station and wash the object out of the eye.

b. A fellow worker has obviously scratched an eyeball in a mishap. You know the worker needs medical help immediately, but first, you should:

(1) Wash the eye clean at an eye wash station.
(2) Apply a sterile dressing, bandage it loosely, and then take the worker to a doctor.
(3) Bandage the eye snugly to keep air out of the scratch.

c. You watch as a coworker accidentally splashes floorwax into his eyes. You know immediately to:

(1) Flush the eye at an eye washing station, and then get medical help.
(2) Bandage the eyes loosely, and then get medical help.
(3) Have the coworker blink his eyes often, and the tears will probably clean the wax from his eyes.

34. Complete statements about guidelines for general first aid emergencies. Circle the information that best completes each of the following statements.

a. Never hesitate to administer (**first aid**) (**help**) when it is needed.

b. Always have (**a reason for**) (**a general plan for**) what you do.

c. Have someone call the nearest medical assistance, 911, or the number of the (**ambulance service**) (**EMS**) in your area.

d. Reassure the injured person that (**something**) (**everything possible**) is being done to help.

e. Make accurate (**written notes**) (**mental notes**) about the accident, including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

Written Test

f. Do not notify the victim's family because this is the responsibility of the school, the jobsite supervisor, or the (**medical facility**) (**emergency medical crew**).

g. Report all accidents and injuries to your instructor or jobsite supervisor, no matter how (**minor**) (**dumb**) they may seem to be.

h. File a (**complete**) (**timely**) accident report and submit a copy to a supervisor or person in charge.

***Permission to duplicate this test is granted.**

Welding Safety and First Aid
Unit 2

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Complete a Student Safety Pledge Rating ______

Comments: ______________________________________

____

Assignment Sheet 2—Respond to First Aid Requirements Rating ______

Comments: ______________________________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______________________________________

____

Teacher Signature ______________________ Date __________

Student Signature ______________________ Date __________

***Permission to duplicate this form is granted.**

Golden Rules for Welding

If you open it, close it.

If you turn it on, turn it off.

If you unlock it, lock it.

If you break it, repair it.

If you can't fix it,

Call someone who can.

If you borrow it, return it.

If you use it, take care of it.

If you make a mess, clean it up.

If you move it, put it back.

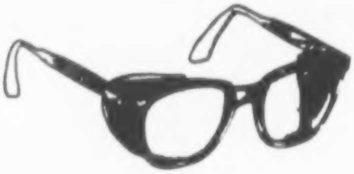
If you don't know how to operate it,

Leave it alone.

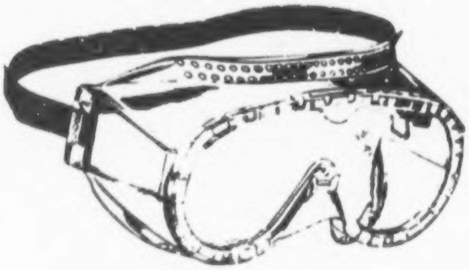
If it doesn't concern you,

Mind your own business.

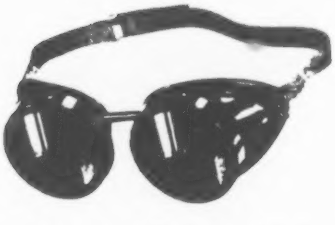
Eye and Face Protection



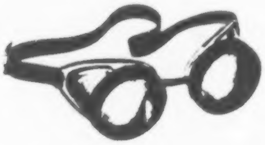
Safety Glasses



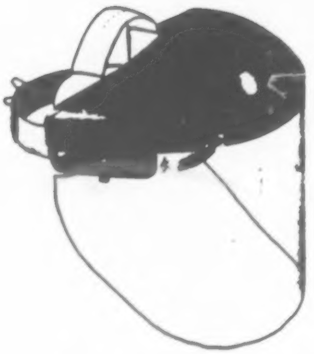
Flexible Goggles



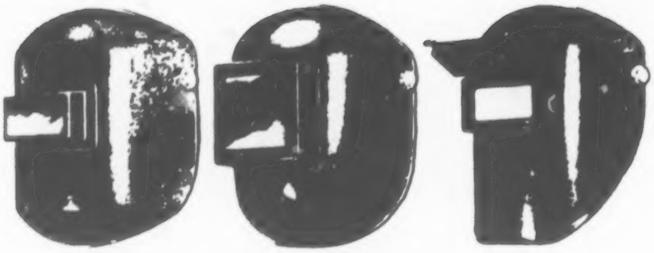
Cutting Goggles



Chipping Goggles

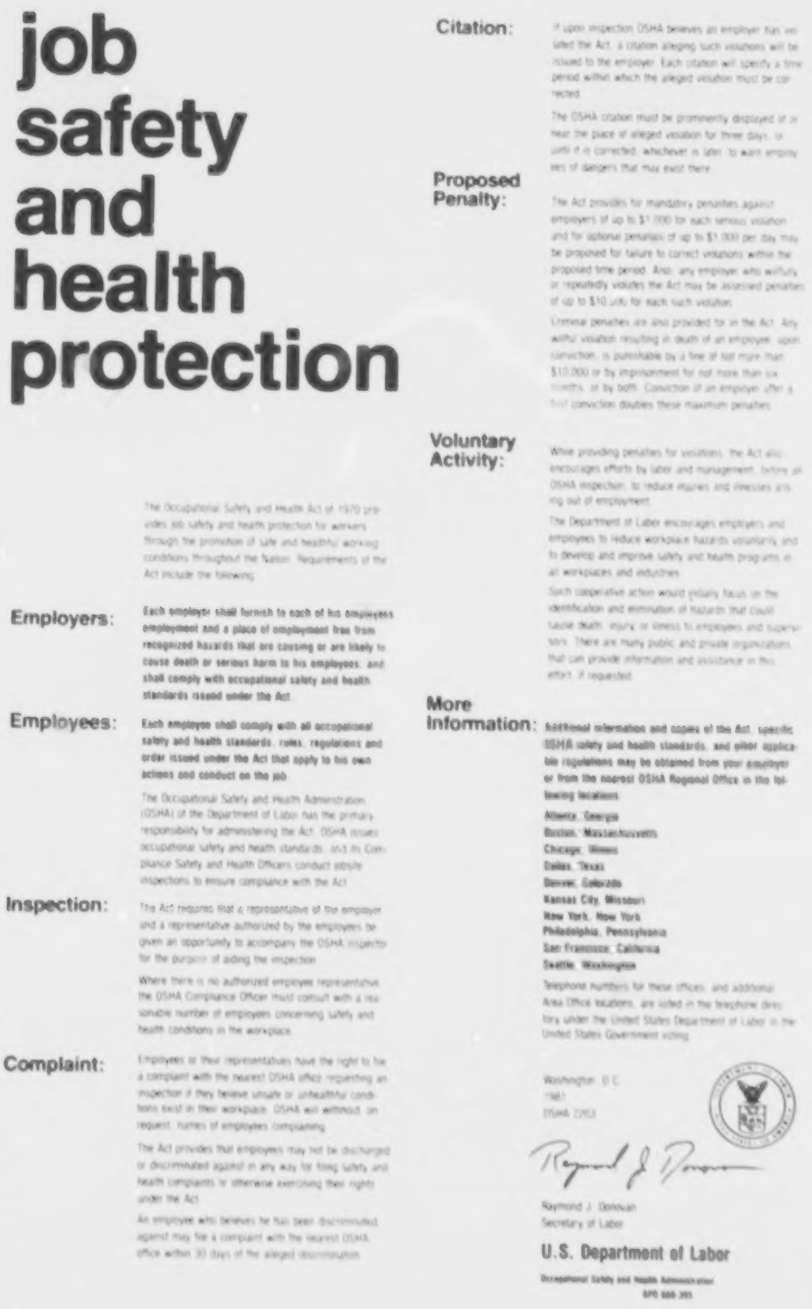


Face Shield



Welding Helments

OSHA Poster #2203



job safety and health protection

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers through the promotion of safe and healthful working conditions throughout the Nation. Requirements of the Act include the following:

Employers: **Each employer shall furnish to each of his employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to his employees; and shall comply with occupational safety and health standards issued under the Act.**

Employees: **Each employee shall comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to his own actions and conduct on the job.**

The Occupational Safety and Health Administration (OSHA) of the Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to ensure compliance with the Act.

Inspection: The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint: Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or otherwise exercising their rights under the Act.

An employee who believes he has been discriminated against may file a complaint with the nearest OSHA office within 30 days of the alleged discrimination.

Citation: If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty: The Act provides for mandatory penalties against employers of up to $1,000 for each serious violation and for optional penalties of up to $1,000 per day may be proposed for failure to correct violations within the proposed time period. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $10,000 for each such violation.

Criminal penalties are also provided for in the Act. Any willful violation resulting in death of an employee, upon conviction, is punishable by a fine of not more than $10,000 or by imprisonment for not more than six months, or by both. Conviction of an employer after a first conviction doubles these maximum penalties.

Voluntary Activity: While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce injuries and illnesses arising out of employment.

The Department of Labor encourages employers and employees to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries.

Such cooperative action would initially focus on the identification and elimination of hazards that could cause death, injury, or illness to employees and supervisors. There are many public and private organizations that can provide information and assistance in this effort, if requested.

More Information: **Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:**

Atlanta, Georgia
Boston, Massachusetts
Chicago, Illinois
Dallas, Texas
Denver, Colorado
Kansas City, Missouri
New York, New York
Philadelphia, Pennsylvania
San Francisco, California
Seattle, Washington

Telephone numbers for these offices, and additional Area Office locations, are listed in the telephone directory under the United States Department of Labor in the United States Government listing.

Washington, D.C.
1981
OSHA 2203

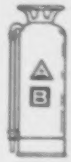
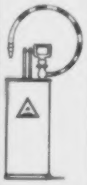
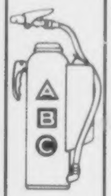
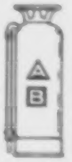
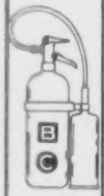
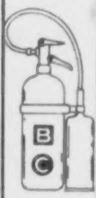
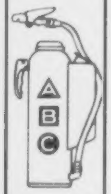
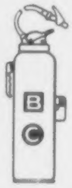
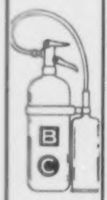
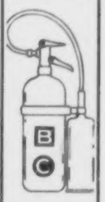
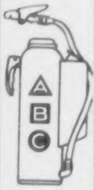
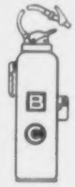
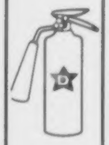
Raymond J. Donovan

Raymond J. Donovan
Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration
GPO 880 395

Fire Safety

Kind of Fire		Approved Type of Extinguisher						
		Match Up Proper Extinguisher With Class of Fire Shown at Left						
Decide the Class of Fire You Are Fighting. . . ↓	**. . . Then Check the Columns to the Right of That Class** →	**Foam** Solution of Aluminum Sulphate and Bicarbonate of Soda	**Carbon Dioxide** Carbon Dioxide Gas Under Pressure	**Halon**	**Pump Tank** Plain Water	**Dry Powder**	**Multi-Purpose Dry Chemical**	**Ordinary Dry Chemical**
A	**Class A Fires** **Use These Extinguishers** → **Ordinary Combustibles:** Wood, Paper, Cloth, etc.		X	X		X		X
B	**Class B Fires** **Use These Extinguishers** → **Flammable Liquids:** Grease, Gasoline, Paints, Oils, Etc.				X	X		
C	**Class C Fires** **Use These Extinguishers** → **Electrical Equipment:** Motors, Switches, Etc.	X			X	X		
D	**Class D Fires** **Use These Extinguishers** → **Combustible Metals:** Magnesium, Iron, Zinc, Etc.	X	X	X	X		X	X

Standard Accident Form

STANDARD STUDENT ACCIDENT REPORT FORM

Part A. Information on ALL Accidents

1 Name ____________________ Home Address ____________________

2 School ____________________ Sex M ☐, F ☐ Age ____ Grade or classification ____

3 Time accident occurred Hour ______ A.M. ______ P.M. Date ____________________

4 Place of Accident: School Building ☐ School Grounds ☐ To or from School ☐ Home ☐ Elsewhere ☐

5. **NATURE OF INJURY**

Abrasion ____
Amputation ____
Asphyxiation ____
Bite ____
Bruise ____
Burn ____
Concussion ____
Cut ____
Dislocation ____
Other (specify) ____________
Fracture ____
Laceration ____
Poisoning ____
Puncture ____
Scalds ____
Scratches ____
Shock (el.) ____
Sprain ____

PART OF BODY INJURED

Abdomen ____
Ankle ____
Arm ____
Back ____
Chest ____
Ear ____
Elbow ____
Eye ____
Face ____
Finger ____
Other (specify) ____________
Foot ____
Hand ____
Head ____
Knee ____
Leg ____
Mouth ____
Nose ____
Scalp ____
Tooth ____
Wrist ____

DESCRIPTION OF THE ACCIDENT

How did accident happen? What was student doing? Where was student? List specifically unsafe acts and unsafe conditions existing. Specify any tool machine or equipment involved ____________________

6 Degree of Injury: Death ☐ Permanent Impairment ☐ Temporary Disability ☐ Nondisabling ☐

7 Total number of days lost from school ______ (To be filled in when student returns to school)

Part B. Additional Information on School Jurisdiction Accidents

8 Teacher in charge when accident occurred (Enter name) ____________________
Present at scene of accident: No ______ Yes ______

9. **IMMEDIATE ACTION TAKEN**

First aid treatment ____ By (Name) ____________________
Sent to school nurse ____ By (Name) ____________________
Sent home ____ By (Name) ____________________
Sent to physician ____ By (Name) ____________________
Physician's Name ____________________
Sent to hospital ____ By (Name) ____________________
Name of hospital ____________________

10 Was a parent or other individual notified? No __ Yes __ When ____________ How ____________
Name of individual notified ____________________
By whom? (Enter name): ____________________

11 Witnesses: 1. Name ____________________ Address ____________________
2. Name ____________________ Address ____________________

12. **LOCATION**

Specify Activity

Athletic field ____________
Auditorium ____________
Cafeteria ____________
Classroom ____________
Corridor ____________
Dressing room ____________
Gymnasium ____________
Home Econ ____________
Laboratories ____________

Specify Activity

Locker ____________
Pool ____________
Sch. grounds ____________
______ shop ____________
Showers ____________
Stairs ____________
Toilets and washrooms ____________
Other (specify) ____________

Remarks

What recommendations do you have for preventing other accidents of this type? ____________

Signed: Principal ____________________ Teacher: ____________________

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Welding Safety and First Aid
Unit 2

Information Sheet

1. **Terms and definitions**

    a. **Arc burn** — A burn on the exterior membrane of the eye caused by exposing the naked eye to the ultra-violet and infra-red rays in the flash of an electric arc, or the exposure of improperly covered body areas to the flash of an electric arc

    b. **Accident** — Any suddenly occurring, unintentional event which causes personal injury or property damage

    c. **Combustibles** — Materials or liquids that catch fire easily

    d. **First aid** — Immediate, temporary care given the victim of an accident or sudden illness until the service of a doctor can be obtained.

    e. **Frostbite** — Skin tissue damage caused by exposure to intense cold

    f. **Hygiene** — The science of good health and its maintenance, including sanitary practices and cleanliness

    g. **OSHA** — The Occupational Safety and Health Administration; federal legislation designed to insure safe and sanitary working conditions for employees

    h. **Safety** — State or condition of being safe; freedom from danger, risk, or injury

    i. **Tetanus** — An acute, infectious disease that usually enters the body through cuts or wounds; characterized by spasmodic contractions or rigidity of some voluntary muscles and frequently referred to as lockjaw

    j. **Tourniquet** — A bandage or strap twisted around a limb to compress the flow of blood through arteries and check severe bleeding; previously a recommended first aid procedure, but now recommended only for life-threatening situations

2. **Safety color codes and their applications**

    a. Safety green

        (1) Applied to nonhazardous parts of machine and equipment surfaces, like nameplates and bearing surfaces
        (2) Designates safe areas of equipment, and is also used to show location of safety equipment and first-aid materials

Information Sheet

b. Safety yellow

  (1) Applied to operating levers, wheels handles, and hazardous parts that may cause stumbling, falling, snagging, or tripping
  (2) Designates caution

c. Safety orange

  (1) Applied to electrical switches, interior surfaces of doors, fuses and electrical power boxes, and movable guards and parts
  (2) Indicates dangerous parts of equipment which may cut, crush, shock, or otherwise physically injure someone

d. Safety red

  (1) Applied to buttons or levers of electrical switches used for stopping machinery, and to all equipment, such as gasoline cans, which are fire hazards
  (2) Designates fire hazards and fire-fighting equipment

  Note: The color red is also applied to other fire-fighting equipment, such as fire alarms, fire axes, and emergency exits.

e. Safety blue

  (1) Used to identify equipment which is being repaired or is defective and should not be operated
  (2) Designates "out of order" or "defective"

f. Safety ivory

  (1) Applied to label edges, vise jaws, and edges of tool rests where extra light reflection is important
  (2) Used to show tool and equipment moving edges more clearly

g. Safety black on safety yellow

  (1) Applied to area where radiation is a factor or danger
  (2) Designates radiation hazards

h. Safety black, safety white, and safety yellow

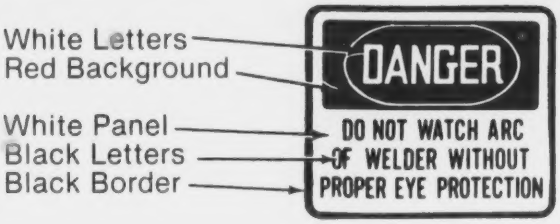
  (1) Applied to floors for safety lanes and location of housekeeping supplies
  (2) The single or combination use of these colors are used to identify traffic flow and housekeeping zones

Information Sheet

3. Accident prevention signs, their colors and uses

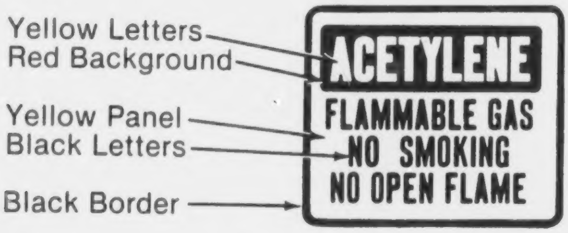
a. Danger signs

(1) Used where an immediate hazard exists
(2) Colors are red, black, and white


White Letters
Red Background
White Panel
Black Letters
Black Border
DANGER
DO NOT WATCH ARC
OF WELDER WITHOUT
PROPER EYE PROTECTION

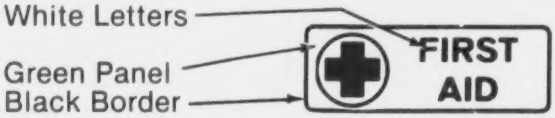
b. Caution signs

(1) Used to warn against potential hazards or to caution against unsafe practices
(2) Colors are yellow and black


Yellow Letters
Red Background
Yellow Panel
Black Letters
Black Border
ACETYLENE
FLAMMABLE GAS
NO SMOKING
NO OPEN FLAME

c. Safety instruction signs

(1) Used where there is a need for general instruction and suggestions relative to safety measures
(2) Colors are white, green, and black


White Letters
Green Panel
Black Border
FIRST
AID

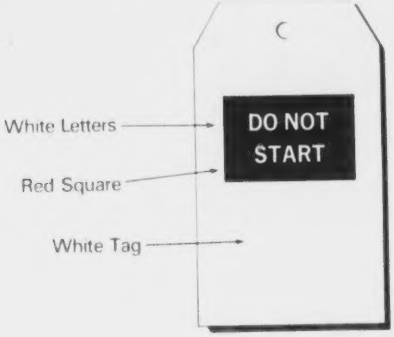
Information Sheet

4. Accident prevention tags, their colors and uses

Note: Tags are for temporary use only.

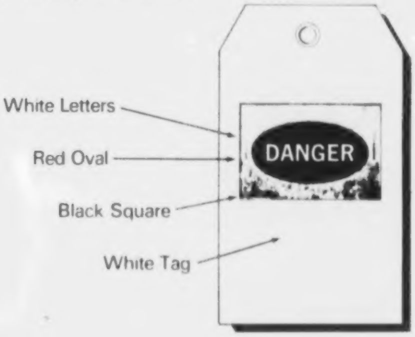
a. Do not start tags

(1) Are placed at the starting mechanism on machines which would be hazardous should the equipment be energized
(2) Colors are red, white, or gray


White Letters
DO NOT START
Red Square
White Tag

b. Danger tags

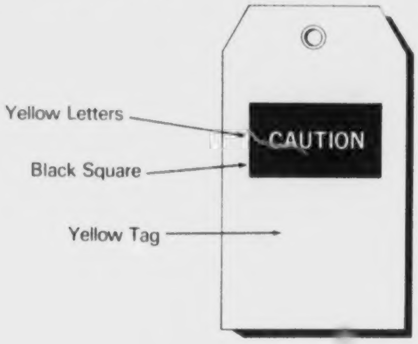
(1) Are placed only where an immediate hazard exists
(2) Colors are red, black, and white


White Letters
Red Oval
DANGER
Black Square
White Tag

Information Sheet

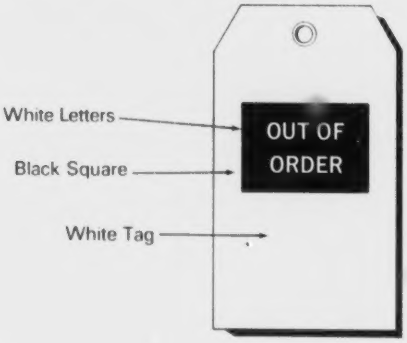
c. Caution tags

  (1) Are used to warn against potential hazards or to caution against unsafe practices
  (2) Colors are yellow and black


Yellow Letters
CAUTION
Black Square
Yellow Tag

d. Out of order tags

  (1) Are used to identify pieces of equipment that are out of order
  (2) Colors are blue and white


White Letters
OUT OF ORDER
Black Square
White Tag

5. **The ALWAYS rules for welding safety**

  a. Always wear suitable protective clothing and eye protection.

  b. Always keep a safe, clean work area.

  c. Always keep welding equipment in good condition.

  d. Always check welding areas to make sure they're safe to work in.

  e. Always respect gas cylinders as dangerous and potentially lethal.

Information Sheet

f. Always make sure ventilation provides three to four complete changes of air per hour.

g. Always look our for fellow students and coworkers.

6. **The NEVER rules for welding safety**

a. Never enter the welding shop without wearing safety glasses.

b. Never weld, cut, or grind near flammable or explosive materials.

c. Never use oil on gas cylinders, regulators, connections, or hoses.

d. Never permit an electrode holder to come in contact with a welding machine or a gas cylinder.

e. Never operate ungrounded equipment.

f. Never cut or weld directly on concrete.

g. Never arc weld or operate electrically powered equipment while standing on wet or damp floors.

h. Never cut into barrels, drums, or any container that has not been purged.

i. Never ground electrical equipment to a building member or a piece of equipment attached to or part of a building.

j. Never engage in horseplay of any kind.

7. **Shop safety rules**

a. Keep all hand tools sharp, clean, and in safe working order.

b. Report any defective tools, machines, or other equipment to the instructor.

c. Keep all guards and safety devices securely in place.

d. Operate a hazardous machine only after receiving instruction on how to operate the machine safely.

e. Report all accidents to the instructor regardless of their nature or severity.

f. Turn off the power before leaving a machine tool.

g. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool.

h. Disconnect the power from machine tools before performing the maintenance tasks of oiling or cleaning.

Information Sheet

8. Eye safety

a. Wear safety glasses at all times in the welding shop.

b. Wear safety glasses and a face shield when grinding, chipping, cutting, or shaping metal with any kind of power tool.

c. If you wear contact lenses, check with your doctor to see if the type of lens you wear requires any special precautions in the work environment.

Note: Reports that an electric arc can burn a contact lens to the cornea of the eye are false, but dust or other contaminants in the air can be irritating to persons who wear contact lenses, and some work environments may merit special precautions for contact lens wearers.

d. Select proper lens shade for the welding or cutting activity and make sure the lens is not chipped, cracked, or damaged.

e. Do not wear plastic-coated lenses for welding or cutting.

f. Remember that lens shade numbers are not additive, in other words, a #8 and a #6 lens will not give the same density as a #14 lens, so don't mix lenses.

g. Wear welding goggles or a welding hood with the proper lens shade for all welding and cutting activity.

Lens Shade Selector Chart

Type of operation	Shade number
Soldering	2
Torch brazing	3 or 4
Oxygen cutting 0 - 1 inch 1 - 6 inches 6 inches and over	 3 or 4 3 or 5 5 or 6
Gas welding 1 - 1/8 inch 1/8 inch to 1/2 1/2 inch and over	 4 or 5 5 or 6 6 or 8
Shielded metal arc welding 1/16, 3/32, 1/8, 5/32 inch electrodes	9 - 14
Arc cutting	12 - 14
Gas metal arc welding	9 - 14
Gas tungsten arc welding Nonferrous, gas metal arc welding 1/16, 3/32, 1/8, 5/32 inch electrodes	9 - 14
Gas tungsten arc welding (ferrous), gas metal arc welding (ferrous) 1/16, 3/32, 1/8, 5/32 inch electrodes	9 - 14

Information Sheet

9. Good housekeeping rules

a. Arrange machinery and equipment to permit safe efficient work practices and ease in cleaning.

b. Store materials and supplies in proper places.

c. Store tools and accessories safely in cabinets, on racks, or other storage bins.

d. Keep working areas and work benches clear and free of debris and other hazards.

e. Keep floors clean and free from obstructions and slippery substances.

f. Keep aisles, traffic areas, and exits free of materials or debris.

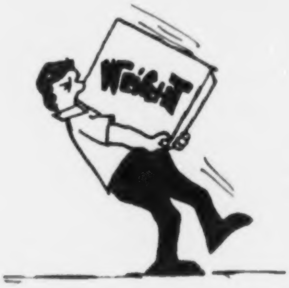
g. Dispose of combustible materials properly or store them in approved containers.

h. Store oily rags in self-closing or spring-lid metal containers.

i. Keep sufficient brooms, brushes, and other housekeeping equipment readily available.

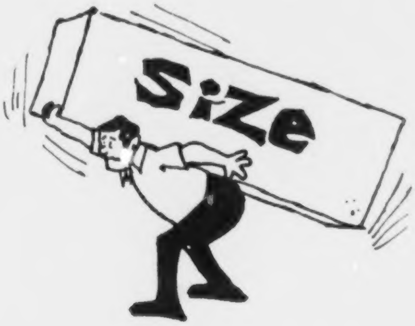
10. Factors contributing to back injuries and their causes

a. Weight—This usually results from overestimating your physical abilities and trying to lift more weight than you can handle, and sometimes it results from trying to be macho in front of fellow workers.

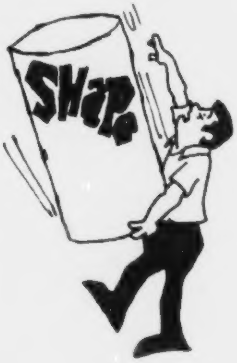


Information Sheet

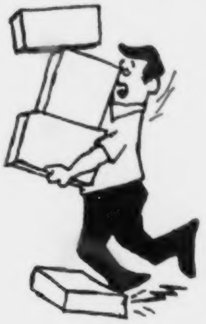
b. Size—This usually results from moving an object that may be within your weight capacity, but too long, high, or wide to lift safely.



c. Shape—This usually results from moving an object that may be within your weight capacity, but has a cylindrical or other odd shape that makes safe lifting difficult.

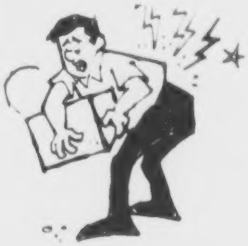


d. Obstructions—This usually results from stacking materials so high that vision is limited and items in the pathway can't be seen.

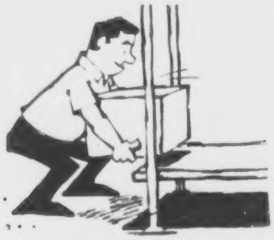


Information Sheet

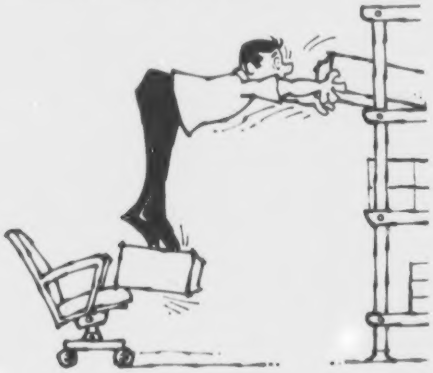
e. Improper position—This usually results from twisting or turning into an awkward position when lifting.



f. Improper storage—This results in strain caused by not storing heavy objects at least 12" off the floor.



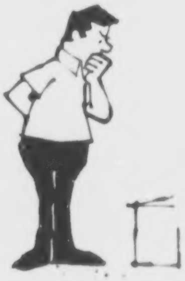
g. Improper reaching—This usually results from carelessly using chairs or boxes to reach from instead of safely using a ladder.



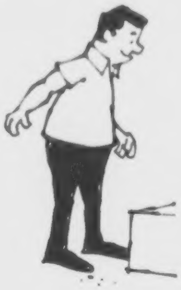
Information Sheet

11. Steps in safe lifting

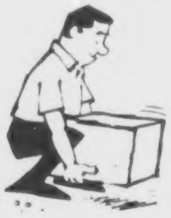
a. Approach the load, size up its weight, size, and shape and consider your physical ability to handle it.



b. Place your feet close to the object to be lifted and keep your feet 8 to 12 inches apart for good balance.

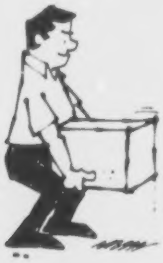


c. Bend your knees to a degree that it is comfortable, get a good hand hold, then use both leg and back muscles to begin the lift.

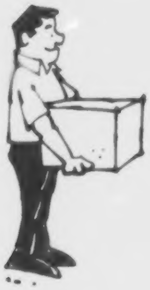


Information Sheet

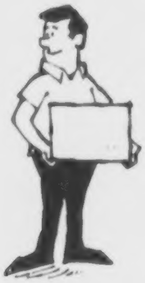
d. Lift the load straight up, smoothly and evenly, while you push with your legs and keep the load as close as possible to your body.



e. Lift the load into carrying position, making no turning or twisting movements until the lift is completed.

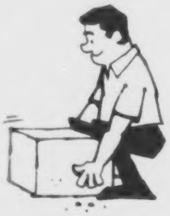


f. Turn your body with changes of foot position while you visually check your path of travel to make sure it is clear.



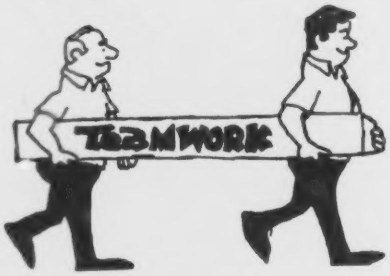
Information Sheet

g. Set the load down by using leg and back muscles together, slowly lower the load by bending your knees, and release your grip only after the load is securely positioned.



h. When lifting or carrying with another worker, make sure the load is equally distributed, and carry long objects at the same level and on the same side of the body.

Note: When moving or carrying large metal sheets, it is especially important to have another worker help.



12. OSHA requirements for employers

a. Provide a hazard-free workplace and comply with occupational safety and health standards.

b. Inspect job sites to assure they meet safety standards.

c. Use properly color-coded signs to warn of danger.

d. Keep required records of work-related injuries, and post an annual summary in February of each year.

e. Report within 48 hours to OSHA any accident which is fatal or hospitalizes five or more workers.

f. Post in a prominent place OSHA poster #2203 informing workers of their rights and responsibilities.

Information Sheet

13. **OSHA requirements for employees**

    a. Read the OSHA poster #2203 and comply with its standards.

    b. Follow employer safety and health rules and wear prescribed clothing or protective equipment on the job.

    c. Report hazardous conditions to a supervisor.

    d. Report all job-related injuries to a supervisor and seek prompt treatment if required.

    e. Report to OSHA in a responsible manner any hazardous working situations which you feel the employer has not attended to properly.

14. **Rules for personal safety**

    a. Wear shop clothing appropriate to the instructional activity being performed, and do not wear greasy clothing.

    b. Confine long hair before operating rotating equipment.

    c. Remove ties when working around machine tools or rotating equipment.

    d. Remove rings and other jewelry when working in the shop, and avoid wearing safety glasses that have wire frames.

    e. Conduct yourself in a manner conducive to safe shop practices.

    f. Do not smoke in restricted areas, and do not carry a butane or propane lighter in your pocket around any welding or cutting activity.

15. **Personal physical and hygiene requirements**

    a. Take a bath or shower daily.

       Note: This should be a matter of personal pride, a matter of habit, but beyond that, it's a responsibility to your fellow workers or classmates.

    b. Stay in good physical condition because this also promotes good psychological health.

Information Sheet

c. Do not drink alcoholic beverages or use drugs on the job, and don't show up for work with a hangover.

Caution: Even at the hangover stage, alcohol impairs judgement and endangers co-workers, and drugs are both physically and psychologically damaging.

d. Pay attention all the time because the majority of accidents happen to beginners in their first few months of work.

16. Types of fires and their classifications

a. Class A — Fires that occur in ordinary combustible materials

Examples: Wood, rags, paper, or trash

b. Class B — Fires that occur in flammable liquids

Examples: Gasoline, oil, grease, paints, and thinners

c. Class C — Fires that occur in electrical and electronic equipment

Examples: Motors, switchboards, circuit wiring, radios, and television sets

d. Class D — Fires that occur in combustible metals

Examples: Powdered aluminum and magnesium

17. Fire safety rules

a. Report immediately anything that might indicate a potential fire hazard.

Example: The sound of wires shorting even though they can't be seen, a light that blinks on and off, and the smell of smoke even when a flame is not visually apparent all indicate potential fire hazards.

b. Know the location and the proper operation of fire extinguishers and make sure they have been recently checked.

c. Know where the nearest telephone is and make sure the number of the nearest fire department is listed on the phone.

d. Know the procedure for evacuating the building and the location of all fire exits in case one or more exits may be blocked.

Information Sheet

e. Smoke only at authorized times and in authorized areas and make sure cigarette butts are completely extinguished and properly discarded.

f. Examine materials and equipment around the workplace to determine what types of fires might occur, then make sure available fire extinguishers are correct for the classes of fires that might occur.

g. Isolate combustible materials in fire-resistant areas.

h. Dispose of rubbish regularly.

i. Conduct fire drills at regular intervals to make sure the alarm can be heard over shop noises, and that everyone knows evacuation routes, exits, and assembly points.

Note: During a fire alarm, students should go to an assembly point predetermined by the instructor, and this point should be used to account for all students who have evacuated the building.

18. Guidelines for oxygen safety

a. Since oxygen under pressure may react violently in the presence of oil or grease, all oxygen fittings and equipment should be kept free of oil and grease.

Caution: Do not use detergent solutions to test for leaks around oxygen cylinders. Many detergents contain oil.

b. Oxygen cylinders should never be stored near highly combustible materials such as acetylene cylinders.

c. Oxygen should be used and stored with the valve end up.

d. Refrigerated oxygen cylinders have a double wall construction to help maintain a vacuum, and such cylinders should be handled with extreme care.

e. Avoid skin contact with liquid oxygen because its extremely low temperature can cause frostbite.

f. Oxygen cylinders should be protected against excessive temperature rises.

Information Sheet

19. Guidelines for acetylene safety

a. Because acetylene burns readily, acetylene cylinders should be kept safely away from open flames.

b. Acetylene cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

c. Never withdraw acetylene from a cylinder at pressure over 15 psi.

d. Never use acetylene from a cylinder that is lying on its side because acetone withdrawn with the acetylene could damage equipment and cause inferior welds.

e. Acetylene cylinders should be protected against excessive temperature rises.

20. Guidelines for other fuel gas safety

a. Propane and MPS (methylacetylene-propadiene stabilized) cylinders should be stored in clean, dry, well ventilated locations free from other combustibles.

b. Both propane and MPS cylinders should be used and stored in an upright position.

c. Natural gas in cylinders should be handled with the same precaution as other fuel gas cylinders.

d. Whether used from a cylinder or from a piped-in supply, natural gas should be used with torches and tips designed for use with natural gas.

21. Guidelines for shielding gas safety

a. In all cases, shielding gases should be used and stored in an upright position.

b. Avoid skin exposure to carbon dioxide and nitrogen because both gases are cold enough to cause frostbite.

c. Because they can displace oxygen in the air, some nonflammable shielding gases such as argon, nitrogen, carbon dioxide, and helium should be stored in well ventilated areas.

22. Rules for handling gas cylinders safely

a. Never use a cylinder cap to lift a cylinder.

b. Never use oil or grease on a cylinder fitting.

c. Never expose a cylinder to excessive heat.

Information Sheet

d. Never roll a cylinder horizontally across a floor.

e. Never tamper with or attempt to repair a cylinder valve, but do report a faulty valve to your instructor immediately.

f. Keep caps on cylinders when they are not in use.

g. Store all cylinders in well ventilated areas.

h. Chain all cylinders, even empty ones, in an upright position.

i. Do not drop cylinders or strike them sharply.

j. Do not use a hammer or wrench to force cylinder valves open.

k. Keep all cylinders away from electrical contact and any welding arc.

l. Close cylinder valves when they are not in use.

m. Never transport cylinders with regulators attached.

23. Guidelines for electrical safety

a. Do not operate electrical equipment without instructions from your instructor.

b. Do not touch live electrical parts or electrodes with your bare hands or exposed skin.

c. Do not operate electrical parts with wet gloves or wet clothing.

Note: To prevent harmful body shocks, keep hands, feet, and clothing dry, and use a dry board or rubber mat when water, moisture, or perspiration cannot be avoided.

d. Never touch an electrode to a grounded surface for these surfaces will become electrically live.

e. Do not operate equipment beyond its rated capacity.

f. Know cable loads and do not use welding cables at currents in excess of their capacity.

g. Replace worn or bare cables to prevent electrical shock or damage to equipment.

Note: Worn cables can be taped provided the tape has an electrical resistance that is the equal to the original insulation.

Information Sheet

h. Make sure all cable connections are tight, because loose connections could cause overheating of cables and electrical terminals.

i. When not in use, never place an electrode holder in contact with a grounded metal surface because it could short circuit the welding machine.

j. Machines must be installed according to national and local electrical codes.

k. Do not adjust or repair any electrical equipment until all power has been disconnected or the electrical breaker has been turned off.

Note: Adjustments or repairs should be done only by authorized persons.

l. Know where all emergency shut down switches are located.

m. All electrical equipment and tools should be properly grounded to prevent injury to the operator.

24. Ways to recognize shock

a. Skin is pale or bluish.

b. Skin may be moist and clammy, even cold to the touch.

c. Victim feels weak.

d. Pulse is rapid and weak.

e. Breathing rate is fast and irregular.

f. Victim may be confused or incoherent.

25. Steps in treating shock

a. Notify your supervisor or instructor IMMEDIATELY.

b. DO NOT DELAY immediate first aid treatment; it can be life saving.

c. Eliminate the causes of shock, control bleeding, or administer artificial respiration if the victim is not breathing.

d. Keep the victim lying down with feet slightly elevated.

Caution: If the victim has sustained a head or chest injury, do not elevate the feet. Leave the victim lying flat, and when in doubt about the nature of the wound, leave the victim lying flat.

e. Cover the victim to retain body heat, but do not make the victim sweat.

f. Give no liquids or food to the victim.

Information Sheet

26. Steps in administering first aid to a victim of electrical shock

a. Safely remove the victim from contact with the source of electricity using the following procedure:

Caution: Do not touch the electrical circuit or the victim unless the power is off or you are insulated.

(1) Turn off the electricity by means of a switch or circuit breaker or cut cables or wires by means of a wood-handled axe or insulated cutters, if available.
(2) Use a dry stick, rope, leather belt, coat, blanket, or any other nonconductor of electricity to separate the victim from the electrical circuit.

b. Call for assistance:

(1) Others in the area may be more knowledgeable than you about treating the victim.
(2) Another person can call for professional medical help while you administer first aid.

c. Check victim's breathing and heartbeat:

Note: **TIME IS LIFE AT THIS POINT**

(1) If a pulse is detectable, but breathing has stopped, administer mouth-to-mouth resuscitation until medical help arrives.
(2) If the heartbeat has stopped, administer cardiopulmonary resuscitation, but only if you have been trained in this technique.

Caution: Cardiopulmonary resuscitation can sometimes cause more harm than good to a victim unless the person administering the first aid has been trained in the proper procedure.

(3) If both heartbeat and breathing have stopped, alternate between cardiopulmonary resuscitation and mouth-to-mouth resuscitation, but only if you have been trained in this technique.

Information Sheet

d. Administer first aid for shock and burns as necessary:

    (1) Use blankets or coats to help keep the victim as warm and comfortable as possible while waiting for help.
    (2) Raise the victim's legs slightly above head level to help prevent shock.
    (3) If the victim has suffered burns, cover your mouth and nostrils with gauze or a clean handkerchief to prevent breathing germs on the victim while treating the burns.
    (4) Wrap the burned area firmly with sterile gauze or clean linen or towels.

Caution: Do not attempt any other treatment of burns.

e. Always continue treatment within your ability until medical help arrives.

27. First aid for minor cuts

a. Clean the cut with mild soap and water, rinse thoroughly with water, and clean again as required.

b. Cover the cut with a dry, sterile dressing.

c. Notify your supervisor or instructor.

d. Always consider tetanus as a potential hazard.

28. First aid for puncture wounds

a. Puncture wounds through the skin need prompt medical attention to avoid sever infection.

b. Clean the wound with soap and water, rinse thoroughly with water, clean again as required, and cover with a dry, sterile dressing.

c. Notify your supervisor or instructor.

d. Always consider tetanus as a potential hazard.

29. First aid for slivers and splinters

a. Deep penetration through the skin by slivers and splinters always carries the risk of infection and should be treated as such.

b. Do not attempt to remove deeply imbedded splinters especially where the area appears to be infected.

c. Notify your supervisor or instructor.

d. Always consider tetanus as a potential hazard.

Information Sheet

30. First aid for thermal burns

a. Give shock treatment to the victim immediately.

b. Remove clothing from the area of the burn, but do not remove material adhering to the burn area.

c. Apply a thick, dry, sterile dressing and bandage snugly to exclude air.

d. If a sterile dressing is not available use a close-woven, white, clean, cloth and bandage snugly.

31. First aid for chemical burns

a. Give shock treatment to the victim immediately.

b. Immediately wash off the chemical with large quantities of running water.

c. Cut off clothing from the affected area.

d. Apply a thick, dry, sterile dressing and bandage snugly to exclude air.

e. If a sterile dressing is not available, use a close-woven, white, clean cloth and bandage snugly.

32. Steps in controlling bleeding

a. Place a compress of sterile gauze or the cleanest available material directly over the bleeding area.

b. Press firmly with your fingers or the palm of one hand.

c. Elevate the bleeding parts above the heart level unless there is evidence of a fracture.

d. If blood soaks through the first compress, place another compress on it but do not remove the first compress.

e. Secure the compress or compresses with a pressure bandage.

f. Treat the victim for shock.

g. If there is a sever life-threatening hemorrhage, AND ONLY AS A LAST RESORT, APPLY A TOURNIQUET.

Caution: If you decide to use a tourniquet, make it tight enough to stop all bleeding. Failure to do so could cause more blood loss because blood will pass into the wounded area through the arteries, but will not return through the veins.

Information Sheet

33. First aid for eye injury

a. Every eye injury should receive immediate first aid attention.

b. Notify your supervisor or instructor immediately.

c. For an apparent minor object in eye, have the person wink several times. If the tears produced by winking do not remove the object, assume that the object is embedded and use the following procedure:

(1) Have the victim close his or her eyes.
(2) Put a piece of moist cotton over the closed lid.
(3) Place a bandage over the cotton.
(4) Get the victim to a doctor as soon as possible.

d. When the eyeball has been obviously scratched or penetrated, apply a sterile dressing, bandage *loosely*, and get medical help immediately.

e. Never permit the victim of an eye injury to rub his or her eye.

f. When in doubt about any eye injury, seek the most immediate medical attention whether it's on the job or in the classroom.

g. Even though damage may be confined to one eye, it is sometimes best to bandage both eyes with a sterile dressing so the victim will not have a tendency to move the damaged eye.

h. For chemical or acid splashes, flush the eyes immediately at an eye-flushing station, or use a bottled, portable flushing solution, then seek immediate medical assistance.

34. Guidelines for general first aid emergencies

a. Never hesitate to administer first aid when it is needed.

b. Always have a reason for what you do.

c. Have someone call the nearest medical assistance, 911, or the number of the Emergency Medical System, EMS, in your area.

Note: All emergency numbers should be posted beside the nearest telephone.

d. Reassure the injured person that everything possible is being done to help.

Note: Hearing the concerned voice of a coworker is psychologically comforting to an injured person and can actually lessen the degree of shock.

Information Sheet

e. Make accurate written notes about the accident, including name of victim, time, place, cause or nature of the accident, and any first aid that was administered.

f. Do not notify the victim's family because this is the responsibility of the school, the jobsite supervisor, or the medical facility.

g. Report all accidents and injuries to your instructor or jobsite supervisor, no matter how minor they may seem to be.

h. File a complete accident report and submit a copy to the proper persons.

Note: Follow emergency procedures that have been adopted by your school.

Note: If your city or town has set up an Emergency Medical System, EMS, be sure to have the phone number posted near.

Welding Safety and First Aid
Unit 2

Assignment Sheet 1—Complete a Student Safety Pledge

Name ________________________ Overall Rating __________

Evaluation criteria	**Rating**
All entries completed and properly dated	______

Student Safety Pledge for Vocational Welding

____________________, who is enrolled in vocational welding studies at ____________________, will, as a part of the training program, operate machines and equipment. This activity requires the written permission of parent (s) or guardian.

It is understood that each student will be given proper instruction in the safe use of machines and equipment before being allowed to operate the machines or equipment alone. Further, the student will be instructed in rules and regulations and safety requirements for classroom and shop activities. The student must assume responsibility for conducting himself/herself in a safe manner, and it is requested that the student sign the following student safety pledge:

1. I PROMISE TO ABIDE BY ALL SAFETY RULES FOR THE SHOP AS FOLLOWS:
   a. To use hand tools and power tools only after proper instruction and only with the instructor's permission.
   b. To use all tools and equipment only for their intended purposes, and to wear safety glasses at all times in the shop area.
   c. To exhibit a concern for tools and equipment by returning them to proper storage areas after use.
   d. To contribute to good housekeeping requirements and to keep the shop area clean and safe.
   e. To abide by all fire regulations and to respect no smoking signs or areas
   f. To avoid horseplay at all times.
   g. To follow all rules and regulations of the school.

Assignment Sheet 1

2. I WILL REPORT ALL ACCIDENTS TO THE INSTRUCTOR IMMEDIATELY.

DATE ________________ STUDENT'S SIGNATURE ____________________________

As parent(s) or guardian of ____________________________, I hereby give consent for my son/daughter to operate all machines and equipment necessary for carrying out the requirements of the welding course in which he/she is enrolled (parent or guardian signature not required for students of legal age.)

DATE ________________

PARENT(S) OR GUARDIAN SIGNATURE ____________________________________

Note: Parents are cordially invited to visit the school and inspect the welding program at any convenient time.

Welding Safety and First Aid
Unit 2

Assignment Sheet 2—Respond to First Aid Requirements

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Correctness of first response	______
Correctness of second response	______

Directions: The following emergency scenarios present situations in which first aid is required. Read the scenarios carefully and provide first and second responses as indicated.

1. A fellow student has suffered a minor cut working with a piece of metal; you have cleaned the cut with mild soap and water and rinsed the cut off, but the cut still looks as if it might have dirt in it.
    a. What would you do next? ______________________________
    b. What would you do after that? ______________________________
2. A fellow student complains of a splinter in her wrist; you examine it and find that the splinter is deeply embedded.
    a. What would you use to remove the splinter? ______________________________
    ____
    b. What would you do next? ______________________________
3. A fellow student has just had a hard bump on the head; a few moments later he complains of feeling weak; you reach over to help him to a chair and notice that his skin feels moist and almost cold to touch.
    a. What is probably wrong? ______________________________
    b. What would you do? ______________________________
4. A fellow student has suffered a bad cut; you have cleaned the cut and applied a compress to it, but in a few moments the compress is bloody and messy.
    a. Should you remove the blood-soaked compress? ______________________________
    b. What would you do next? ______________________________

Assignment Sheet 2

5. A fellow student has suffered an eye injury, and it appears that a small piece of metal may be embedded in the eyeball.

   a. What would you do first? ______

   b. What would you do next? ______

6. A fellow student has suffered an eye injury; nothing appears to be embedded in the eyeball and the rest of the eye appears to be free of any foreign matter, but the student complains of great pain.

   a. What should you do if this happens in the school shop? ______

   ______

   b. What should you do if this happens on the job? ______

   ______

7. You have just assisted in administering first aid to a fellow worker with a bad cut; the cut has been cleaned, the compress that was applied is doing a good job, and everything is under control.

   a. What should you do next? ______

   ______

   b. What should you do after that? ______

   ______

Welding Tools and Equipment
Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify basic hand tools, power tools, and equipment, and state their characteristics. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding tools and equipment with their correct definitions.
2. Match driving and chipping tools with their characteristics and uses.
3. Match chisels, punches, and pry bars with their uses.
4. Select true statements about characteristics and uses of files.
5. Complete statements about types and uses of wire brushes.
6. Select true statements about vise-grip® clamps and their uses.
7. Match holding and anchoring tools with their uses.
8. Match alignment tools with their uses.
9. Complete statements about types of jacks and their uses.
10. Match pulling and lifting tools with their characteristics and uses.
11. Match measuring tools with their characteristics and uses.
12. Match layout tools with their characteristics and uses.
13. Match turning tools and wrenches with their uses.

Objective Sheet

14. Match pliers with their uses.
15. Match manual cutting and shaping tools with their uses.
16. Match manually-operated shop tools with their characteristics and uses.
17. Match power equipment with its characteristics and uses.
18. Match power saws with their characteristics and uses.
19. Match positioning equipment with its characteristics and uses.
20. Complete statements about rules for hand tool safety.
21. Select true statements about basic rules for safe use of power tools and equipment.
22. Select true statements about rules for tool and equipment maintenance.
23. Identify basic hand tools. (Assignment Sheet 1)
24. Identify basic power tools and equipment. (Assignment Sheet 2)

Welding Tools and Equipment
Unit 3

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TMs 1 and 2—Right and Wrong Tool Use (Objectives 13 and 14)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheets. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

Suggested Activities

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skill areas have been adapted by MAVCC.

1. Have available the tools required for each objective. Demonstrate proper tool use as you teach each objective. Wear safety glasses or a face shield as required when demonstrating tool use. Impress students with the importance of learning how to properly use tools for not just the sake of safety, but for tool longevity and the protection of valuable working materials from damage through improper tool use. Skill area: **learning to learn** using tools effectively.

2. Take advantage of the objectives that discuss measuring and shaping tools to demonstrate how math functions in welding activities ranging from joint design to fit up. To enhance the "math concept, invite the carpentry instructor or a carpentry student from your school to demonstrate to the class how complex a simple framing square really is. Show how linear increments are used to find angles for roof pitch and rafter design. Use a bevel square to document all measurements. Skills area: accomplishing **math** functions with common tools.

3. If you have a student who carries a tool box in the trunk of a car or on the back of a pickup, have the student estimate the cost of the tools that are there. Talk to students about the cost of tools. Stress these points when you teach the final objective on tool maintenance.

4. Teach and reteach safety every chance you get, especially with Objectives 17, 18, and 19 that deal with power equipment.

Suggested Activities

Resources Used in Developing This Unit

1. Fortney, Clarence and Mike Gregory. *Introduction to Welding*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.
2. Moses, Napoleon W. *Hand Tools for Welding*. Mississippi State, MS: Research and Curriculum Unit for Vocational-Technical Education, College of Education, Mississippi State University, 1982.
3. *Heavy Duty Power Tools for Industry and Construction*. Hampstead, MD: The Black & Decker Manufacturing Company, 1980.
4. Althouse, Andrew D., et. al. *Modern Welding*. South Holland, IL: The Goodheart-Willcox Co., Inc., 1989.
5. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1991.

Suggested Supplemental Resources

1. *Welding Technology*, the first volume of the American Welding Society's updated welding handbook series, dedicates Chapter 9 to fixtures and positioners. The chapter concludes with a supplementary reading list that offers many other useful resources too numerous to list here.
2. Updated tools and equipment catalogs were frequently available from area wholesale houses, but catalogs of that nature have become so expensive to produce that many of them are relatively old. However, many wholesalers will supply vendor catalogs and other materials that frequently appear in catalog form. Companies such as Proto, Stanley, Kline, and Cooper (the company that makes Crescent wrenches and Nicholson files) do provide area wholesalers with catalogs in quantity, and the catalogs should be available from a nearby source.

Welding Tools and Equipment
Unit 3

Answers to Assignment Sheets

Assignment Sheet 1

a. Chipping hammer
b. Mallet
c. Ball peen hammer
d. Cold chisel
e. Drift punch
f. Card file
g. Wire brush
h. Screw-type C-clamp
i. Spring clamp
j. Wedge
k. Strongback
l. Hydraulic jack
m. Turnbuckle
n. Come-along
o. Plumb line and bob
p. Combination square

Assignment Sheet 2

a. Power roll
b. Drill press
c. Pedestal buffer
d. Belt and disc sander
e. Cut-off saw
f. Vertical band saw
g. Horizontal band saw
h. Turning roll
i. Positioner
j. Manipulator

Welding Tools and Equipment
Unit 3

Answers to Written Test

1. a. 3
   b. 5
   c. 7
   d. 1
   e. 6
   f. 2
   g. 4

2. a. 2
   b. 4
   c. 1
   d. 5
   e. 3

3. a. 3
   b. 5
   c. 2
   d. 6
   e. 1
   f. 4

4. a, b, c, e

5. a. Before and after
   b. Stainless steel

6. a, b, e, g

7. a. 5
   b. 4
   c. 1
   d. 3
   e. 2

8. a. 1
   b. 2
   c. 3

9. a. Mechanical
   b. Hydraulic

10. a. 4
    b. 1
    c. 2
    d. 3

11. a. 8
    b. 5
    c. 3
    d. 7
    e. 6
    f. 2
    g. 4
    h. 1

Answers to Written Test

12.
a. 4
b. 8
c. 2
d. 7
e. 3
f. 6
g. 1
h. 5

13.
a. 4
b. 9
c. 5
d. 7
e. 8
f. 3
g. 1
h. 2
i. 6

14.
a. 3
b. 2
c. 1
d. 4

15.
a. 3
b. 1
c. 5
d. 2
e. 4

16.
a. 3
b. 4
c. 1
d. 2

17.
a. 9
b. 4
c. 8
d. 3
e. 7
f. 2
g. 10
h. 6
i. 1
j. 5

18.
a. 4
b. 2
c. 5
d. 1
e. 3

19.
a. 3
b. 2
c. 1

20.
a. Screwdriver
b. Pliers
c. Loose handle
d. Screwdriver
e. Pull it toward
f. A file
g. Small
h. Punch or chisel

21. a, b, c, e, g, h, i, j

22. a, b, c, d

Welding Tools and Equipment
Unit 3

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

______a. The measured thickness of metal or wire, or an instrument to measure thickness

______b. A form or frame used to mass produce a part or to control distortion during a welding process

______c. A metal-cutting machine with operating power from a clutch or a flywheel that provides high-speed operation

______d. A metal-cutting machine with operating power from fluid transport lines to provide a slower rate of operation than other shears

______e. A metal-cutting machine with operating power from compressed air transport lines to provide a slower rate of operation than other shears

______f. Extremely hard, precisely shaped, metal molds used on a press brake for forming angles and shapes in metal

______g. Platforms or bases designed to secure and manipulate welded products so that welding can usually be accomplished from an advantageous position to increase welding speed and weld quality

1. Hydraulic shear
2. Dies and punches
3. Gauge
4. Positioners
5. Jig
6. Pneumatic shear
7. Mechanical shear

Written Test

2. Match driving and chipping tools with their characteristics and uses.

_______a. Used to remove slag and residue left on metals after welding or cutting

_______b. A heavy hammer with two driving heads used to drive wedges under and between materials; comes in weights of 40, 48, or 64 ounces

_______c. Used where a metal hammer would dent or damage material; made of hickory, rawhide, lead, nylon, rubber, or other nonsparking materials

_______d. A long-handled hammer used when more driving force is needed than a small hammer can deliver; comes in weights from 2 to 20 pounds

_______e. A general purpose hammer with a curved face and a rounded head; comes in weights from 4 to 48 ounces.

1. Mallets
2. Chipping hammer
3. Ball peen hammer
4. Fitter's or engineer's hammer
5. Sledge hammer

3. Match chisels, punches, and pry bars with their uses.

_______a. Used for cutting metal, rivets, nuts, and bolts

_______b. Used for cutting keyways in metal

_______c. Used for cutting V-grooves and cleaning out inside corners

_______d. Used for cutting U-shaped grooves in metal

_______e. Used for driving out straight or tapered pins

_______f. Used for prying, positioning, and aligning parts in fit up

1. Drift punch
2. Diamond-point chisel
3. Cold chisel
4. Aligning pry bar
5. Cape chisel
6. Round-nose chisel

Written Test

4. Select true statements about characteristics and uses of files. Place an "X" beside each true statement.

______a. Files are used manually to remove metal stock.

______b. The shape of a file may be triangular, flat, square, round or rat-tail, or half-round to provide a shape to match the job need.

______c. Basic file cuts range from single-cut coarse to double-cut smooth to provide textures that produce specific finishes.

______d. A card file is used to sharpen files.

______e. A file handle is used to cover the tang of a file and protect against injury.

5. Complete statements about types and uses of wire brushes. Circle the information that best completes each of the following statements.

a. Wire brushes are used for cleaning a weld area (**before**) (**before or after**) welding.

b. Wire brushes have steel wire bristles or (**copper**) (**stainless steel**) bristles with shoe handles or bent handles.

6. Select true statements about vise-grip® clamps and their uses. Place an "X" beside each true statement.

______a. Use a curve-jaw clamp to hold round objects like brads and rivet heads.

______b. Use a straight-jaw clamp to hold nuts and bolts, but do not use a straight-jaw clamp on brass fittings.

______c. Use a C-clamp to hold flat objects.

______d. Use a long-reach C-clamp to hold long, flat objects.

______e. Use a welding clamp to hold metal workpieces, especially heated stock that needs to be quenched.

______f. Use a sheet metal clamp to hold angle iron or other structural shapes.

______g. Use a chain clamp to hold or turn round stock, tube, or pipes.

Written Test

7. Match holding and anchoring tools with their uses.

   _______a. Used to hold materials together until they can be joined by other means; these can hold longer and wider materials than other devices

   _______b. Used to hold two or more pieces of material together until they can be joined by other means; these are often used for distortion control

   _______c. Used for light duty to secure a tape line to workpiece or to secure light detail material onto a main workpiece

   _______d. Used to secure workpieces that cannot or should not be held with hand tools

   _______e. Used to eliminate welding and bending jigs; has special accessories to assist with layout and welding activities

   1. Spring clamps
   2. Platen table
   3. Vises
   4. Screw-type C-clamps
   5. Bar clamps

8. Match alignment tools with their uses.

   _______a. Used to fit up two or more pieces of material by inserting a V-shaped end in between pieces so that striking the head or opposite end with a hammer will obtain vertical or horizontal alignment

   _______b. Used as a restraining devices so that wedges can be applied and driven

   _______c. Used as restraining devices so that wedges cam be applied and driven in situations where other devices would not provide enough strength

   1. Wedges
   2. Clip plates or dogs
   3. Flat bar, yoke, and strongback

9. Complete statements about types of jacks and their uses. Circle the information that best completes each statement.

   a. (**Mechanical**) (**Hydraulic**) screw jacks and ratchet lever jacks are used to lift and hold materials in place at levels that make welding easier.

   b. (**Mechanical**) (**Hydraulic**) jacks are used for lifting or lowering loads too heavy to be safely handled by other types of jacks.

Written Test

10. Match pulling and lifting tools with their characteristics and uses.

______a. Used to adjust lengths of wire rope or steel rod; they are adjustable for taking up slack to induce a load or being slacked off to reduce a load

______b. Used as manually operated hoists; they are portable, easy to setup, and may be constructed with chain or cable

______c. Used to lift large metal plates safely and move them from one place to another

______d. Cables and hooks or chains and hooks used in single, double, triple, or quadruple arrangement for lifting and moving heavy objects

1. Come-alongs
2. Plate dogs
3. Slings
4. Turnbuckles

11. Match measuring tools with their characteristics and uses.

______a. Used to measure work points and straight line distances up to 25 feet

______b. Used to measure work points and straight line distances greater than 25 feet

______c. Used to measure the thickness or gauge of sheet metal, steel plate, and wire

______d. Used to assure that drill tips being sharpened are kept centered at an angle of 59° so that they will cut faster with less applied force

______e. Used to construct small circles and arcs and transfer measurements

______f. Used for straight line measurements, but especially used for critical inside/outside measurements of holes, casings, and pipes

1. Rules
2. Calipers
3. American and U.S. Standard metal gauges
4. Micrometers
5. Steel tape
6. Wing dividers
7. Drill point gauge
8. Pocket tape

Written Test

______g. Used to measure the inside, outside, or depth of parts that require tolerances

______h. Measuring devices graduated in whole units and fractions for measuring distances ranging from fractions of an inch up to 48 inches

12. Match layout tools with their characteristics and uses.

______a. Used to check surface alignment horizontally, vertically, or at angles

______b. Used primarily by fitters to check the trueness of pipe flanges, but it is also used for checking bevel square angles

______c. Use to layout bevels or to check materials cut on a bevel

______d. Used to square detail materials with the square head used for finding 45° and 90° angles, the protractor head for finding angles from 0° to 180°, and the center head for finding the center of round materials

______e. Used to check vertical alignment of related members in a project or workpiece

______f. Used to check for straightness in plate and structural materials by permitting a chalk line to be snapped onto the surface of a workpiece

______g. Used to make puncture marks, to locate the centers of holes, or to establish work points or center lines on materials

______h. Use most often to make punch marks along layout lines to provide permanent references for chalked or scribed lines that might wear off in handling

1. Center punch
2. Bevel square
3. Plumb line and bob
4. Levels
5. Prick punch
6. Chalk line
7. Combination square
8. Framing square

Written Test

13. Match turning tools and wrenches with their uses.

_______a. Used to tighten or loosen different sizes of nuts and bolts

_______b. Used to tighten or loosen specific sizes of nuts and bolts

_______c. Used to tighten or loosen specific sizes of nuts and bolts, but the head has closer control of the gripping surface than other types of wrenches

_______d. Used primarily for fitting up pipe, but handy for holding and aligning because of its vise-like adjustable jaws

_______e. Used specifically for tightening or loosening cylinder connections on oxyacetylene equipment because adjustable wrenches can easily damage the brass fittings used on oxyacetylene equipment

_______f. Used specifically for tightening or loosening torch connections because adjustable wrenches or pliers can damage brass fittings

_______g. Used to tighten or loosen specific types of screws, bolts, and other anchoring devices that have slotted heads

_______h. Key-type wrenches used to tighten or loosen specific sizes of special screws or bolts

_______i. Used with a variety of end sizes and handles to tighten or loosen different sizes of nuts and bolts that may be difficult to reach or require extra torque to tighten or loosen

1. Screwdrivers
2. Allen wrenches
3. Torch wrenches
4. Adjustable wrench
5. Box-end wrench
6. Socket wrench sets
7. Pipe wrench
8. Cylinder wrenches
9. Open-end wrench

Written Test

14. Match pliers with their uses.

_______a. Used for handling hot metal or materials

_______b. Used for cutting small diameter wire, especially wire used in gas metal arc welding

_______c. Used for cleaning cups and nozzles, for cutting small diameter wire, for holding, and bonding, and for general work around gas tungsten arc welding

_______d. Used to cut larger diameter wire, for holding and for general use around submerged arc welding

1. Needle nose
2. Diagonal cutters
3. Slip joint
4. Lineman's

15. Match manual cutting and shaping tools with their uses.

_______a. Used to manually cut or separate metal

_______b. Used to cut straight lines or curves on light-gauge metal

_______c. Used to cut small diameter nuts, bolts, rod, and chain

_______d. Used for cutting small-diameter pipe or tubing

_______e. Used to cut inside threads in metal or to cut outside threads on pipe or other round stock

1. Straight-cut snips
2. Pipe cutters
3. Hacksaw
4. Tap and die sets
5. Bolt cutters

16. Match manually-operated shop tools with their characteristics and uses.

_______a. Used to cut, notch, and bend this basic stock form

_______b. Used to bend, form, and shape pipe, tubing, angle iron, flat bars, and straps

_______c. Lever operated bench tool that makes distortion free cuts in straight or curved patterns on light to heavy metals

_______d. An iron or steel block with both flat and curved surfaces for shaping metals that are hammered or peened against it

1. Beverly shear
2. Anvil
3. Angle iron cutter, notcher, and bender
4. Hossfeld bender

Written Test

17. Match power equipment with its characteristics and uses.

______a. Uses mechanical, hydraulic, or pneumatic power to cut all gauges of metal

______b. Used to shape both plate and structural metals into rounded forms

______c. Used for grinding all forms of metal

______d. Used on metals to polish or buff with wire, brush, or cloth wheels

______e. Generally used with attachments for cleaning joints before or after a welding process

______f. Used to grind or sand flat metal surfaces

______g. Generally used for light drilling jobs; designed with variable or reversible speed in ¼", ⅜", and ½" sizes

______h. Generally used for drilling thick materials; designed with variable or reversible speed in ½", ¾" and 1¼" sizes

______i. Used for drilling holes in several pieces of metal at one time or drilling angle holes in heavier metal

______j. Used with different dies and punches to press metal into a desired shape

1. Drill press
2. Belt and disc sander
3. Pedestal buffer
4. Power roll
5. Press brake
6. Heavy duty hand drill
7. Angle and straight grinders
8. Pedestal grinder
9. Power shear
10. Hand drill

18. Match power saws with their characteristics and uses

______a. Used with a continuous cutting blade for cutting mild steel

______b. Used with a continuous cutting blade to cut any length or type of metal

1. Reciprocating saw
2. Horizontal band saw
3. Cut-off saw

_______c. Used with a reciprocating blade to cut any length or type of metal

_______d. Used like a key-hole saw with various types of blades to cut wood, metal, plastic, and even heavy steel

_______e. Used to cut heavier metal at different angles or in straight cuts

4. Vertical band saw
5. Power hacksaw

19. Match positioning equipment with its characteristics and uses

_______a. Used in production or with automatic equipment that requires pipes or round objects to be rolled

_______b. Used to control and position welding equipment on automatic positioners or turning rolls in production shops with automatic welding processes

_______c. Used to secure and position objects being welded; can turn or rotate an object at a preset speed or can be controlled manually by an operator

1. Positioners
2. Manipulators
3. Turning rolls

20. Complete statements about rules for hand tool safety. Circle the material that best completes each statement.

a. Never use a (**screwdriver**) (**hammer**) as a prying tool.

b. Never use (**pliers**) (**socket wrenches**) to loosen or tighten nuts and bolts.

c. Never use any tool with a (**loose handle**) (**sharp edge**) or defective part.

d. When using a (**combination wrench**) (**screwdriver**), support the work on a bench or against a solid surface.

e. When using a wrench, (**pull it toward**) (**push it away from**) yourself to prevent smashing your hand if the wrench should slip.

f. Never use (**a file**) (**any tool**) without a handle.

g. Secure (**small**) (**large**) parts or objects before working on them with hand tools.

h. Never strike the mushroomed head of a (**punch or chisel**) (**screwdriver**).

Written Test

21. Select true statements about rules for safe use of power tools and equipment. Place an "X" beside each true statement.

_______a. Do not use power tools until you have been instructed how to safely use them, and have permission from your instructor.

_______b. Check electrical cords and plugs before using electrical power tools, and check lines and connections before using air-operated tools.

_______c. When working with a drill press, always clamp the workpiece in place or it will spin with the drill bit.

_______d. Make sure shields and guards are removed if they obstruct a workpiece.

_______e. Avoid walking into restricted safety zones marked off around power equipment.

_______f. When using extension cords with power equipment, make sure they are extra long.

_______g. Do not wear loose or frayed clothing around rotating equipment.

_______h. Pay attention to safety signs and warning tags.

_______i. Know emergency shut-down procedures for all power equipment.

_______j. Keep tools clean and dry.

22. Select true statements about rules for tool and equipment maintenance. Place an "X" beside each true statement.

_______a. The number one rule for maintaining a tool or a piece of equipment is to use it only for its intended purpose.

_______b. Tag and report any tool or piece of equipment suspected of being faulty.

_______c. Record the type of service and date information placed on lubrication and maintenance schedules.

_______d. Always disconnect the power supply when performing maintenance on power tools and equipment.

_______e. Check tool rests on pedestal grinders monthly.

_______f. Check grinding wheels monthly and dress as needed.

_______g. Check oil pressure on shears monthly.

***Permission to duplicate this test is granted.**

Welding Tools and Equipment
Unit 3

Unit Evaluation Form

Student Name ________________________ Unit Rating __________

Assignment Sheet 1—Identify Basic Hand Tools Rating _____

Comments: ____

____

Assignment Sheet 2—Identify Basic Power Tools and Equipment Rating _____

Comments: ____

____

Written Test Scores

Pretest _____ Posttest _____ Other _____

Other ____

____

Teacher Signature ________________________ Date __________

Student Signature ________________________ Date __________

***Permission to duplicate this form is granted.**

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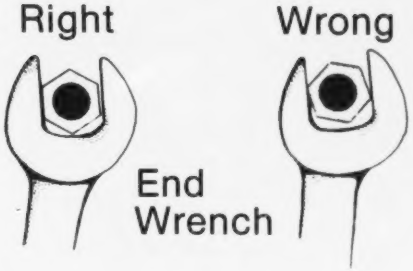
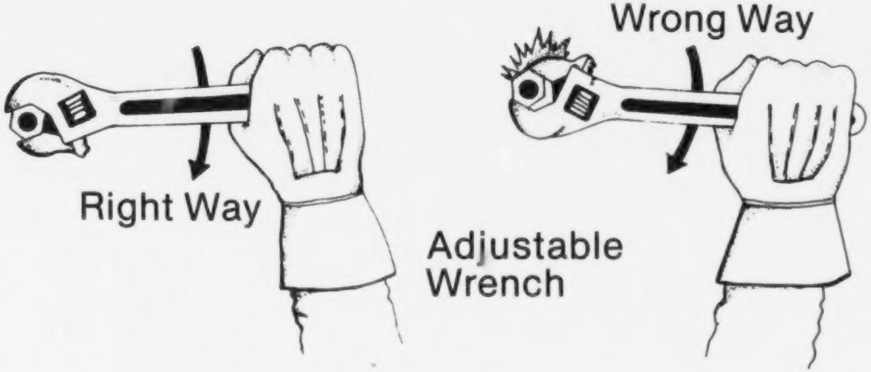
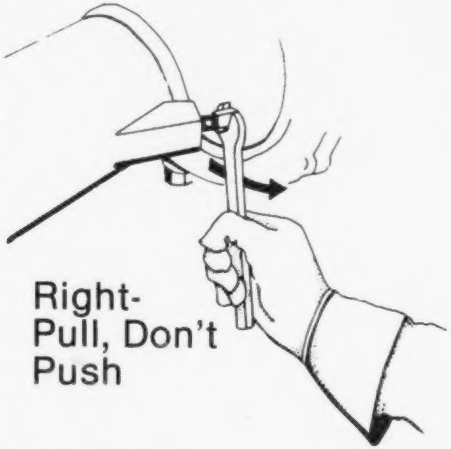
Right and Wrong Tool Use


Right
Wrong

End Wrench

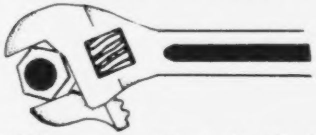

Right Way
Wrong Way

Adjustable Wrench

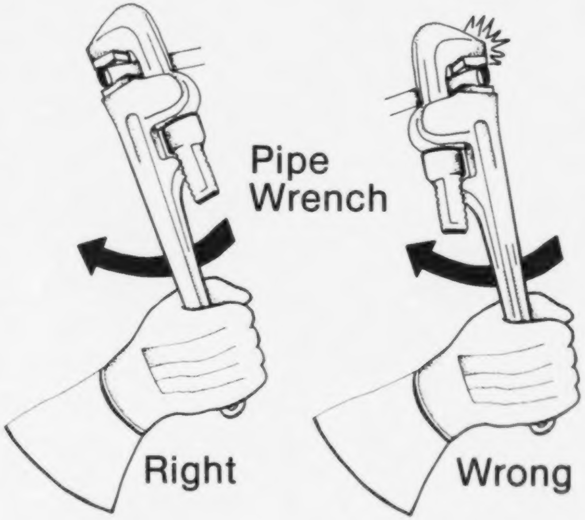


Right- Pull, Don't Push

End Wrench- Adjustable Wrench



Wrong - Don't Pull on an Adjustable Wrench Until It has Been Tightened on the Nut

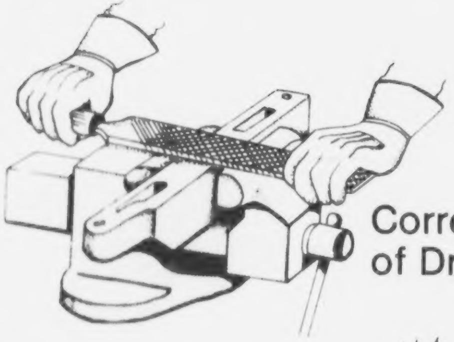

Right
Wrong

Pipe Wrench

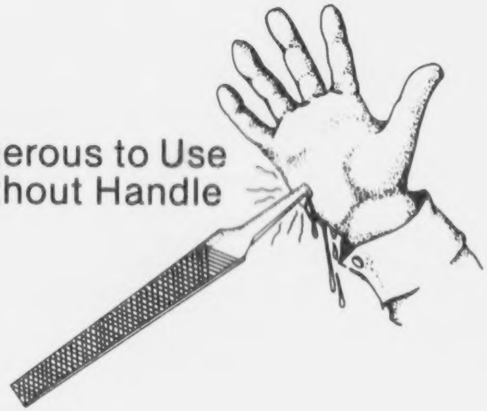
Fundamentals of Welding, Unit 3
Teacher Page 23

TM 1

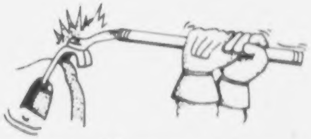
Right and Wrong Tool Use
(Continued)



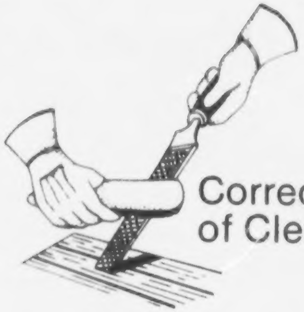
Correct Method of Draw-Filing



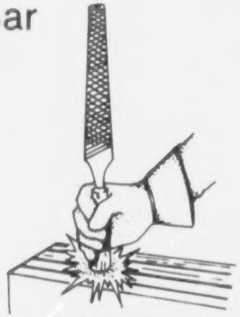
It is Dangerous to Use a File Without Handle



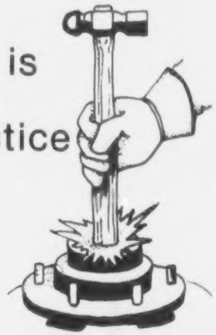
Wrong - Never Use a Bar or a Pipe on a Wrench



Correct Method of Cleaning a File



Correct Method of Tightening File Handle



This is Bad Practice

Incorrect Use of a Hammer

Fundamentals of Welding, Unit 3
Teacher Page 25

TM 2

Welding Tools and Equipment
Unit 3

Information Sheet

1. **Terms and definitions**

   a. **Dies and punches** — Extremely hard, precisely shaped, metal molds used on a press brake for forming angles and shapes in metal

   b. **Gauge** — The measured thickness of metal or wire, or an instrument to measure thickness

   c. **Hydraulic shear** — A metal-cutting machine with operating power from fluid transport lines to provide a slower rate or operation than a mechanical shear

   d. **Jig** — A form or frame used to mass produce a part or to control distortion during a welding process

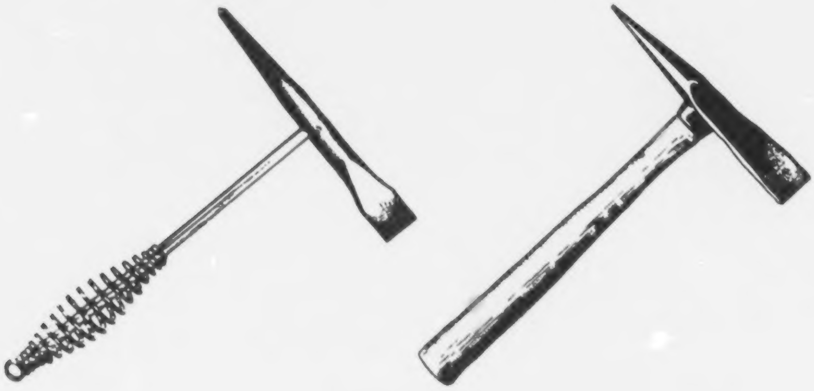
   e. **Mechanical shear** — A metal-cutting machine with operating power from a clutch or a flywheel that provides high-speed operation

   f. **Pneumatic shear** — A metal-cutting machine with operating power from compressed air transport lines to provide a slower rate of operation than a mechanical shear

   g. **Positioners** — Platforms or bases designed to secure and manipulate welded products so that welding can usually be accomplished from an advantageous position to increase welding speed and weld quality

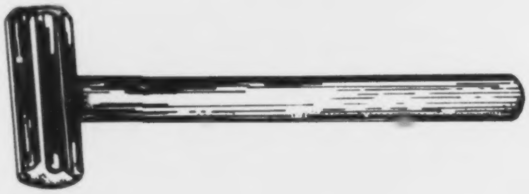
2. **Characteristics and uses of driving and chipping tools**

   a. **Chipping hammer** — Used to remove slag and residue left on metals after welding or cutting

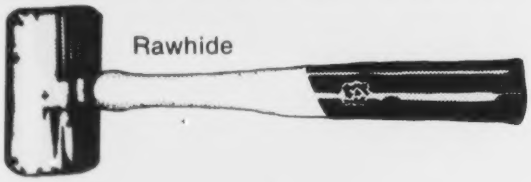


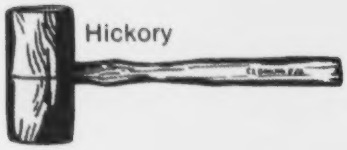
Information Sheet

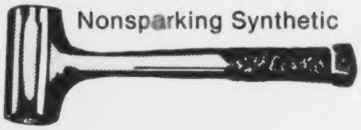
b. **Fitter's or engineer's hammer** — A heavy hammer with two driving heads used to drive wedges under and between materials; comes in weights of 40, 48, or 64 ounces



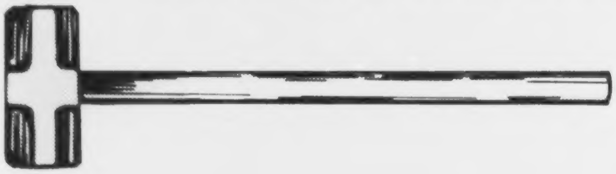
c. **Mallets** — Used where a metal hammer would dent or damage material; made of hickory, rawhide, lead, nylon, rubber, or other nonsparking material



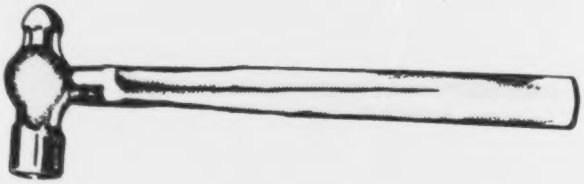




d. **Sledge hammer** — A long-handled hammer used when more driving force is needed than a smaller hammer can deliver; comes in weights of 2 to 20 pounds



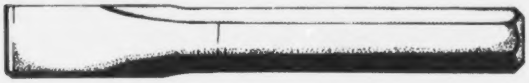
e. **Ball peen hammer** — A general purpose hammer with a curved face and a rounded head; comes in weights from 4 to 48 ounces, and is usually used with one hand



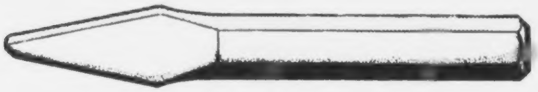
Information Sheet

3. **Chisels, punches, and pry bars and their uses**

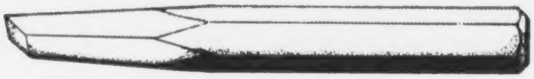
    a. **Cold chisel** — Used for cutting metal, rivets, nuts, and bolts



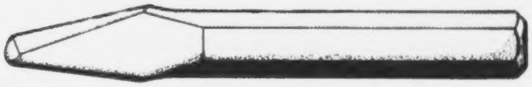
    b. **Cape chisel** — Used for cutting keyways in metals



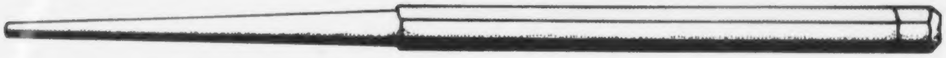
    c. **Diamond-point chisel** — Used for cutting V-grooves and cleaning out inside corners



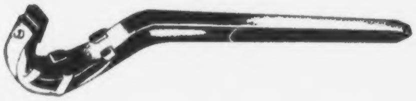
    d. **Round-nose chisel** — Used for cutting U-shaped grooves in metal



    e. **Drift punch** — Used for driving out straight or tapered pins



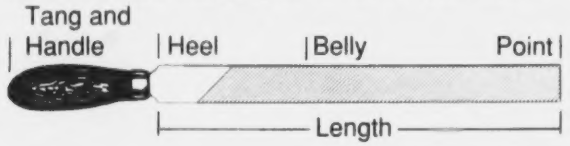
    f. **Aligning pry bar** — Used for prying, positioning, and aligning parts in fit up



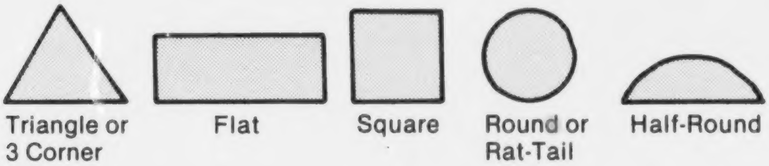
Information Sheet

4. Characteristics and uses of files

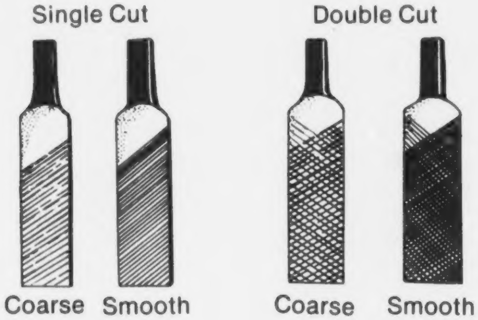
a. Files are used manually to remove metal stock.


Tang and Handle
Heel
Belly
Point
Length

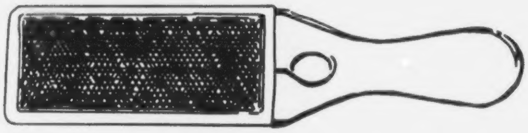
b. The shape of a file may be triangular, flat, square, round or rat-tail, or half-round to provide a shape to match the job need.


Triangle or 3 Corner
Flat
Square
Round or Rat-Tail
Half-Round

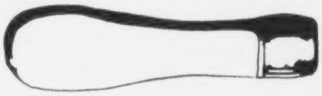
c. Basic file cuts range from single-cut coarse to double-cut smooth to provide textures that produce specific finishes.


Single Cut
Double Cut
Coarse
Smooth
Coarse
Smooth

d. A card file is used to clean a file.



e. A file handle is used to cover the tang of a file and protect against injury.

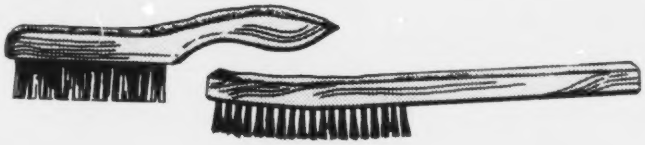


Information Sheet

5. Types and uses of wire brushes

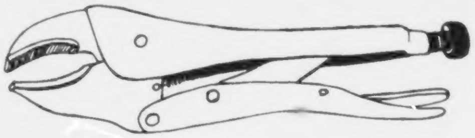
a. Wire brushes are used for cleaning a weld area before or after welding.

b. Wire brushes have steel wire bristles or stainless steel bristles with shoe horn shape or straight handles.

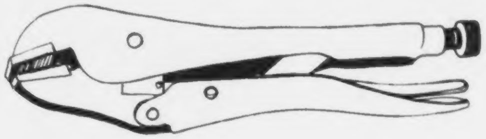


6. Vise-grip® clamps and their uses

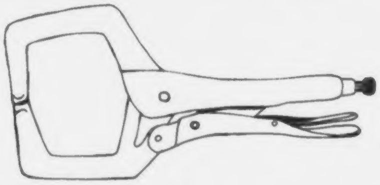
a. Use a curve-jaw clamp to hold round objects like brads and rivet heads.



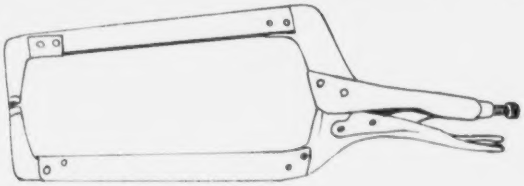
b. Use a straight-jaw clamp to hold nuts and bolts, but do not use a straight-jaw clamp on brass fittings.



c. Use a C-clamp to hold irregular-shaped objects.

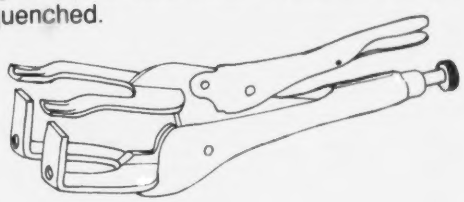


d. Use a long-reach C-clamp to hold long, irregular-shaped objects.

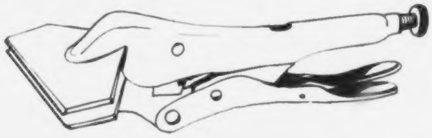


Information Sheet

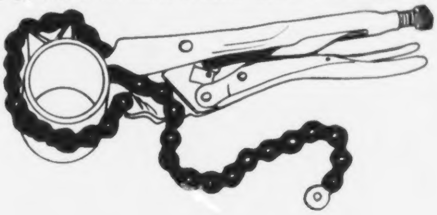
e. Use a welding clamp to hold metal workpieces, especially heated stock that needs to be quenched.



f. Use a sheet metal clamp to hold flat, thin pieces of sheet metal.



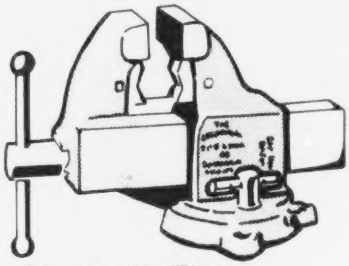
g. Use a chain clamp to hold or turn round stock, tube, or pipes.



7. Holding and anchoring tools and their uses

a. **Vises** — Used to secure workpieces that cannot or should not be held with hand tools

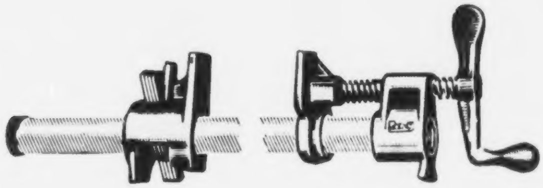
Note: The combination/pipe vise is popular in welding shops because it can be used with both flat stock and pipe.



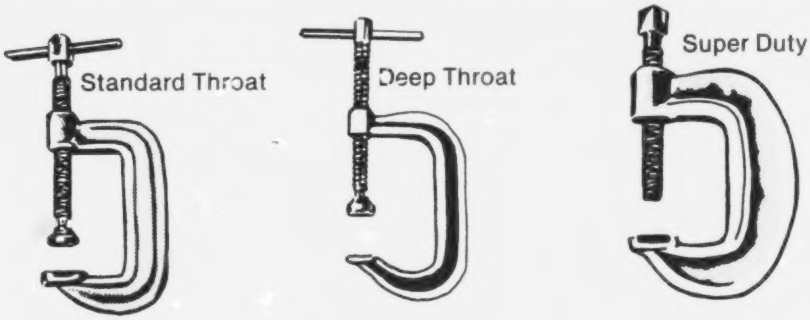
Combination/Pipe

Information Sheet

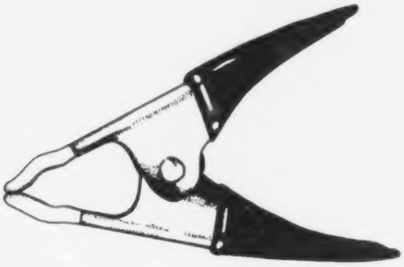
b. **Bar clamps** — Used to hold materials together until they can be joined by other means; bar clamps can hold longer, wider materials than vises can



c. **Screw-type C-clamps** — Used to hold materials together until they can be joined by other means; these clamps are often used for distortion control

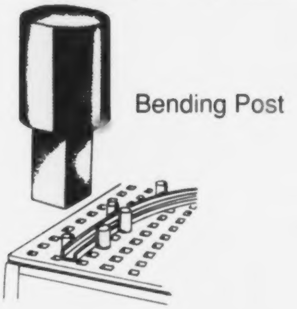


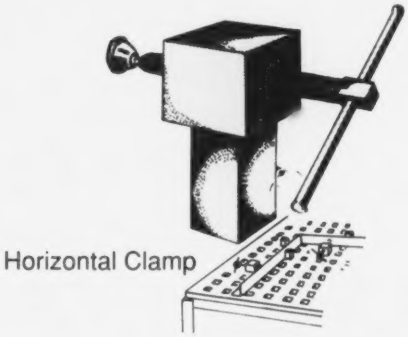
d. **Spring clamps** — Used for light duty to secure a tape line to a workpiece or to secure light detail material onto a main workpiece



Information Sheet

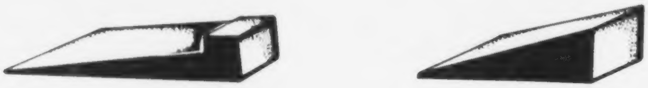
e. **Platen table** — Used to eliminate welding and bending jigs; has accessories to assist with layout and welding activities



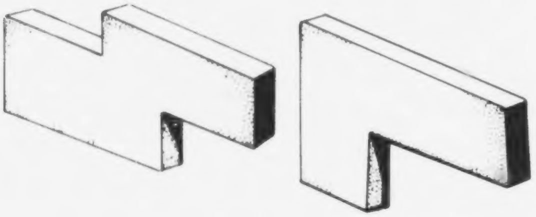


8. Alignment tools and their uses

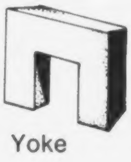
a. **Wedges** — Used to fit up two or more pieces of material by inserting a V-shaped end in between pieces so that striking the head or opposite end with a hammer will obtain vertical or horizontal alignment

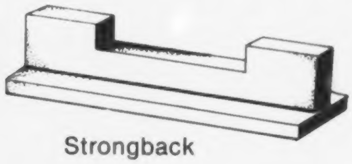


b. **Clip plates or dogs** — Used as a restraining device so that wedges can be applied and driven



c. **Flat bar, yoke, and stongback** — Used as restraining devices so that wedges can be applied and driven in situations where clip plates or dogs would not provide enough strength

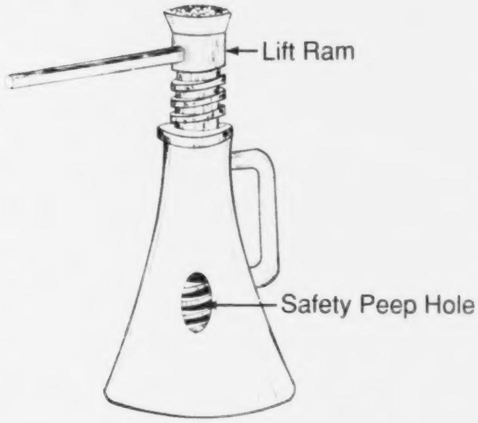




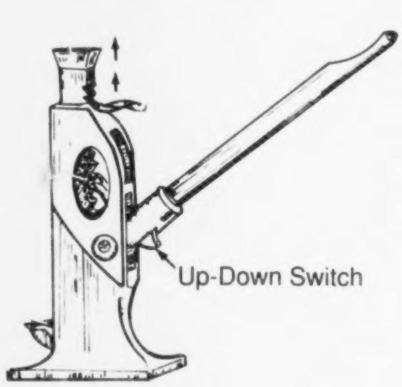
Information Sheet

9. Types of jacks and their uses

a. Mechanical screw jacks and ratchet lever jacks are used to lift and hold materials in place at levels that make welding easier.

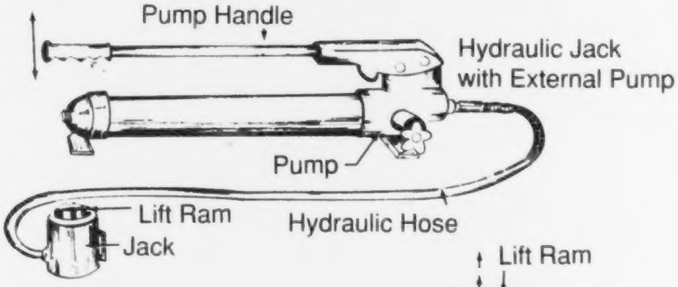

Lift Ram
Safety Peep Hole

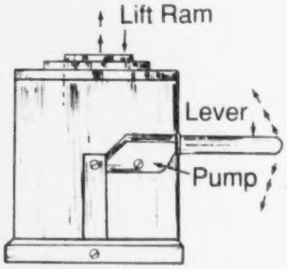
Screw Jack


Up-Down Switch

Ratchet Lever or Railroad Jack

b. Hydraulic jacks are used for lifting or lowering loads too heavy to be safely handled by mechanical jacks.


Pump Handle
Hydraulic Jack with External Pump
Pump
Lift Ram
Jack
Hydraulic Hose


Lift Ram
Lever
Pump

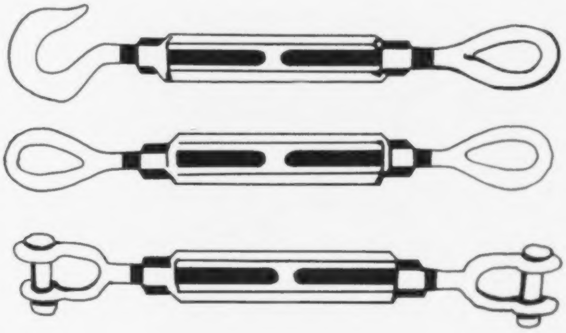
Self-Contained Hydraulic Jack

Illustrations courtesy Research and Curriculum Unit for Vocational-Technical Education, College of Education, Mississippi State University, Mississippi State, Mississippi

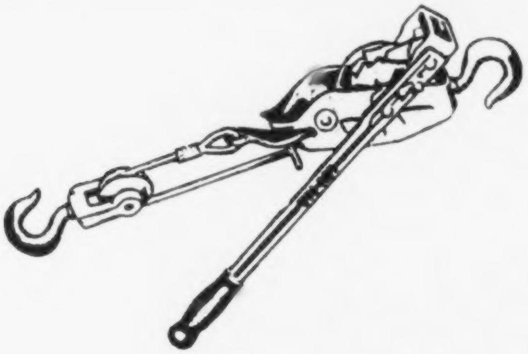
Information Sheet

10. Pulling and lifting tools and their characteristics and uses

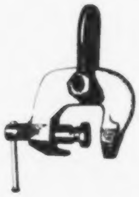
a. **Turnbuckles** — Used to adjust lengths of wire rope or steel rod; they are adjustable for taking up slack to induce a load or being slacked off to reduce a load

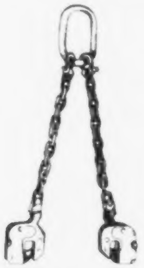


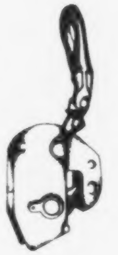
b. **Come-alongs** — Used as manually operated hoists; they are portable, easy to set up, and may be constructed with chain or cable



c. **Plate dogs** — Used to lift large, metal plates safely and move them from one place to another

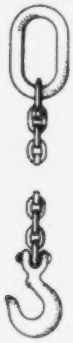


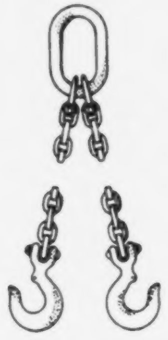


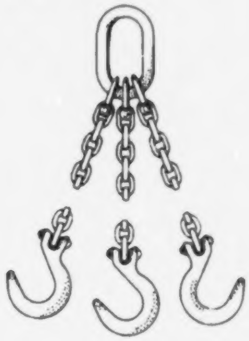


Information Sheet

d. **Slings** — Cables and hooks or chains and hooks used in single, double, triple, or quadruple arrangement for lifting and moving heavy objects

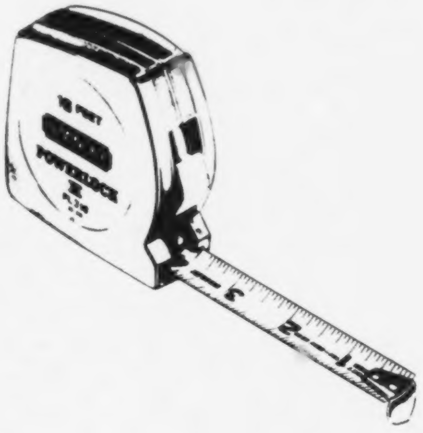




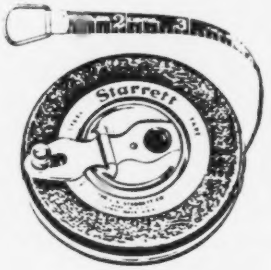


11. Measuring tools and their characteristics and uses

a. **Pocket tape** — Used to measure work points and straight line distances up to 25 feet

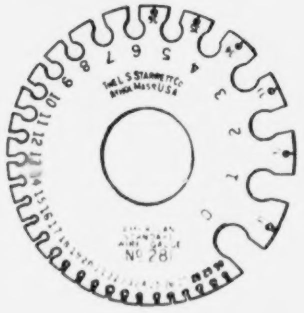


b. **Steel tape** — Used to measure work points and straight line distances greater than 25 feet

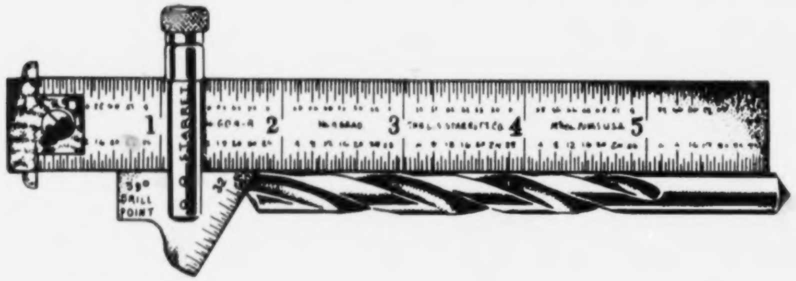


Information Sheet

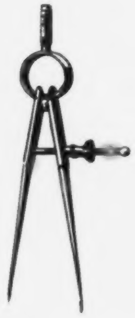
c. **American and U.S. Standard metal gauges** — Used to measure the thickness or gauge or sheet metal, steel plate, and wire


THE L.S. STARRETT CO. ATHOL MASS U.S.A.
No 281

d. **Drill point gauge** — Used to assure that drill tips being sharpened are kept centered at an angle of 59° so that they will cut faster with less applied force

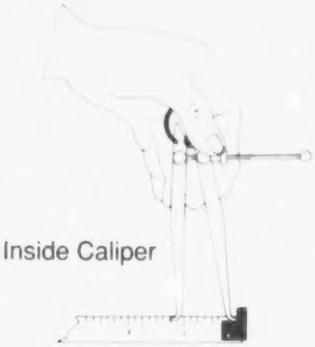

STARRETT
59° DRILL POINT

e. **Wing dividers** — Used to construct small circles and arcs and transfer measurements

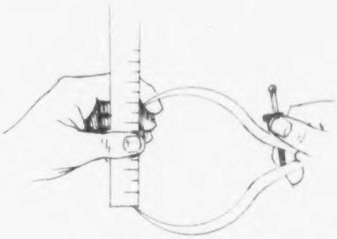


Information Sheet

f. **Calipers** — Used for straight line measurements, but especially used for critical inside/outside measurements of holes, casings, and pipes

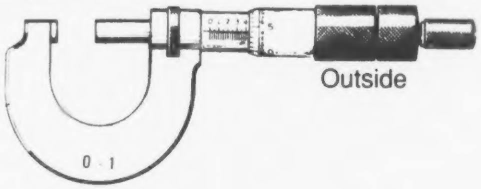


Inside Caliper

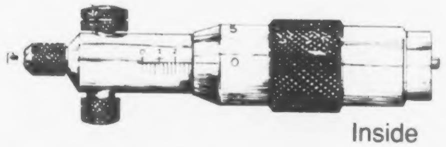


Outside Caliper

g. **Micrometers** — Used to measure the inside, outside, or depth of parts that require critical tolerances



Outside

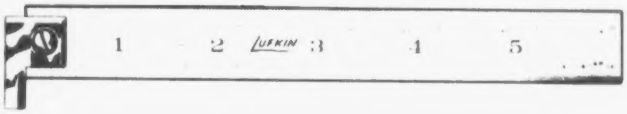


Inside

h. **Rules** — Measuring devices graduated in whole units and fraction for measuring distances ranging from fractions of an inch up to 48 inches

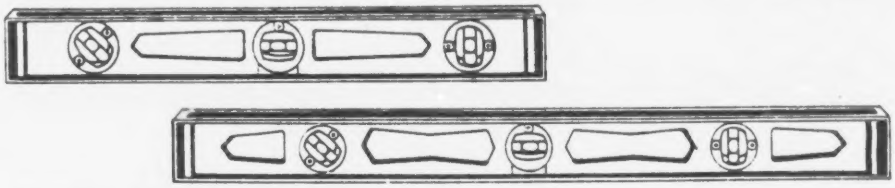
(1) Steel rule

(2) Hook rule

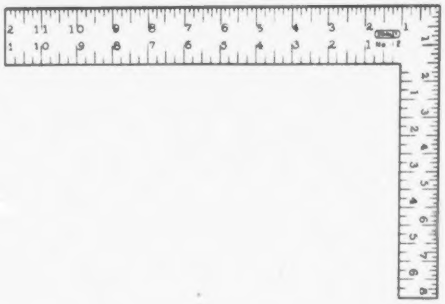


12. Layout tools and their characteristics and uses

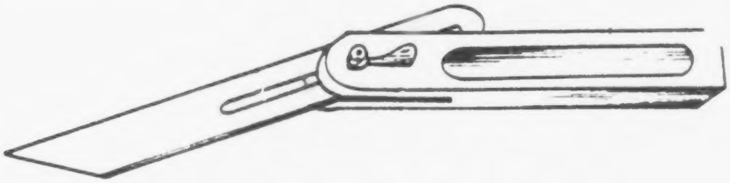
a. **Levels** — Used to check surface alignment horizontally, vertically, or at angles



b. **Framing square** — Used primarily by fitters to check the trueness of pipe flanges, but it is also used for checking bevel square angles

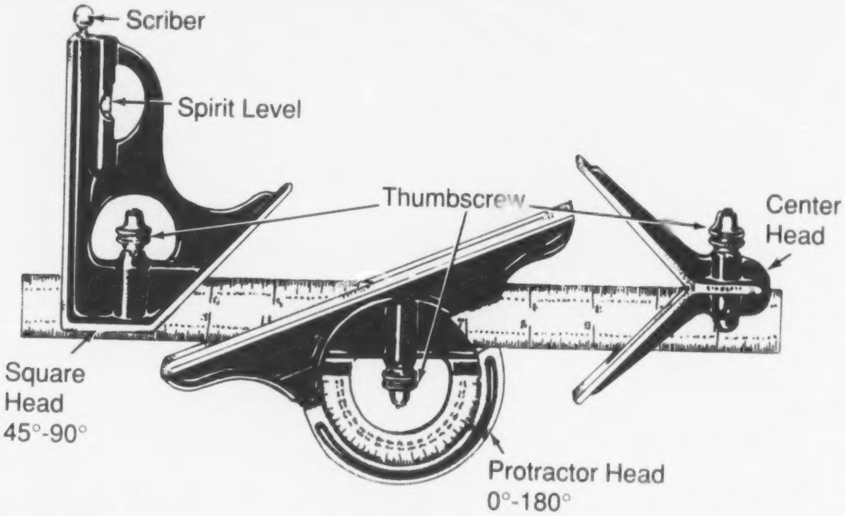


c. **Bevel square** — Used to lay out bevels or to check materials cut on a bevel

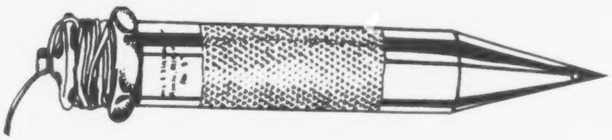


Information Sheet

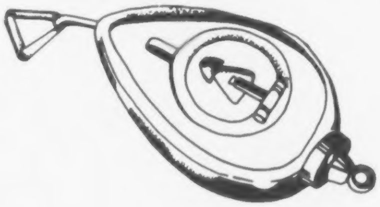
d. **Combination square** — Used to square detail materials with the square head used for finding 45° and 90° angles, the protractor head used for finding angles from 0° to 180°, and the center head used for finding the center of round materials


Scriber
Spirit Level
Thumbscrew
Center Head
Square Head 45°-90°
Protractor Head 0°-180°

e. **Plumb line and bob** — Used to check vertical alignment of related members in a project or workpiece

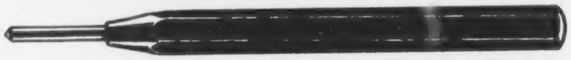


f. **Chalk line** — Used to check for straightness in plate and structural metals by permitting a chalk line to be snapped onto the surface of a workpiece

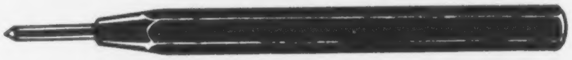


Information Sheet

g. **Center punch** — Used to make puncture marks, to locate the centers of holes, or to establish work points or center lines on materials

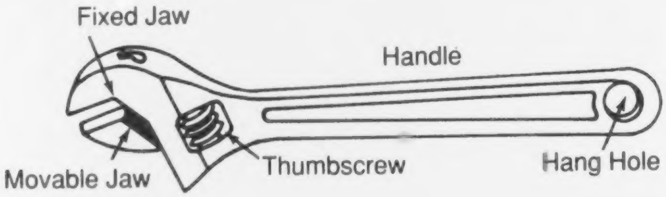


h. **Prick punch** — Used most often to make punch marks along layout lines to provide permanent references for chalked or scribed lines that might wear off in handling

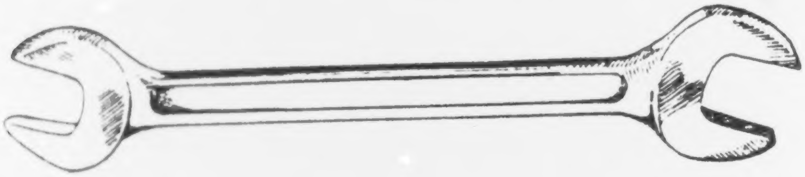


13. **Turning tools and wrenches and their uses**

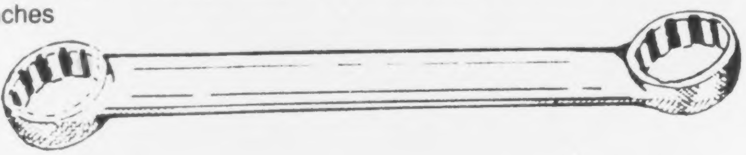
a. **Adjustable wrench (Crescent wrench)** — Used to tighten or loosen different sizes of nuts and bolts



b. **Open-end wrench** — Used to tighten or loosen specific sizes or nuts and bolts

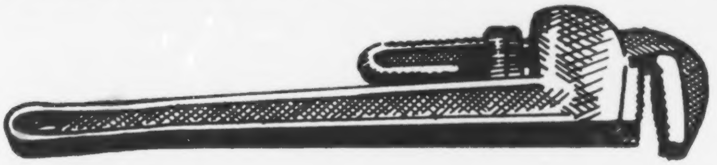


c. **Box-end wrench** — Used to tighten or loosen specific sizes of nuts and bolts, but the head has closer control of the gripping surfaces than other types of wrenches

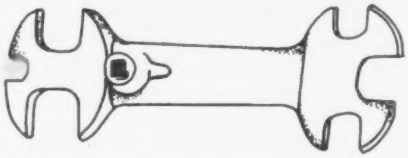


Information Sheet

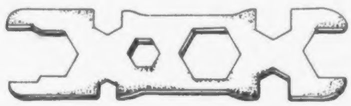
d. **Pipe wrench** — Used primarily for fitting up pipe, but handy for holding and aligning because of its vise-like adjustable jaws



e. **Cylinder wrenches** — Used specifically for tightening or loosening cylinder connections on oxyacetylene equipment because adjustable wrenches can easily damage the brass fittings used on oxyacetylene equipment

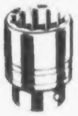


f. **Torch wrenches** — Used specifically for tightening or loosening torch connections because adjustable wrenches or pliers can damage brass fittings

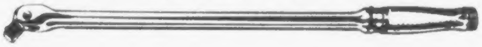


g. **Socket wrench sets** — Used with a variety of socket sizes and handles to tighten or loosen different sizes of nuts and bolts that may be difficult to reach or require extra torque to tighten or loosen

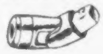
Socket



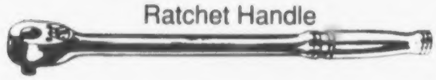
Break-Over Handle



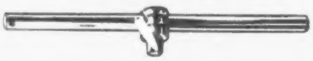
Universal Joint



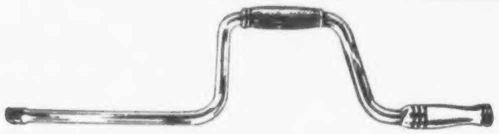
Ratchet Handle



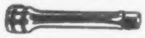
Sliding T-Handle



Speed Handle

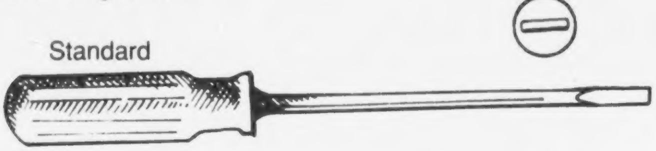


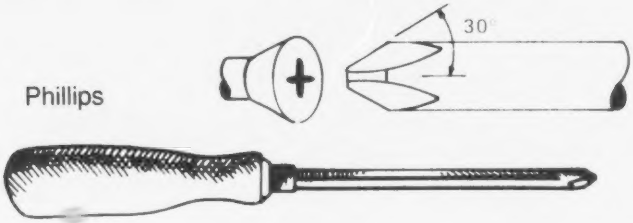
Extension



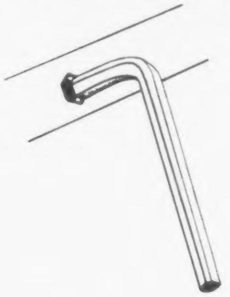
Information Sheet

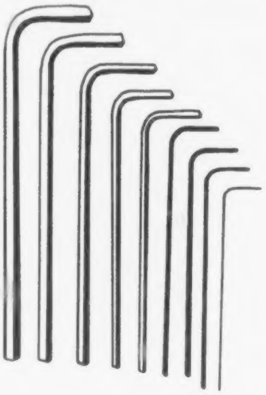
h. **Screwdrivers** — Used to tighten or loosen specific types of screws, bolts, and other anchoring devices





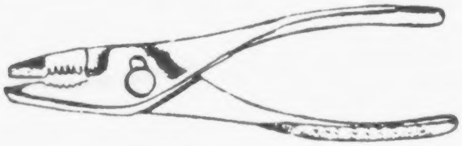
i. **Allen wrenches** — Key-type wrenches used to tighten or loosen specific sizes of Allen screws or bolts





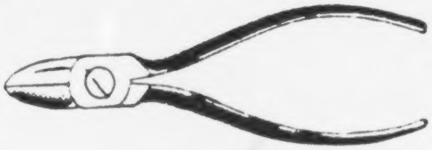
14. Pliers and their uses

a. **Slip joint** — Used for handling hot metal or materials

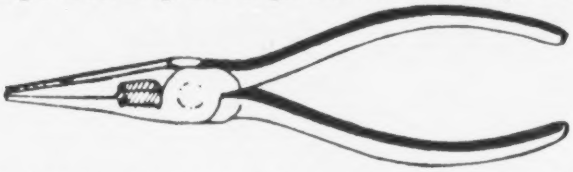


Information Sheet

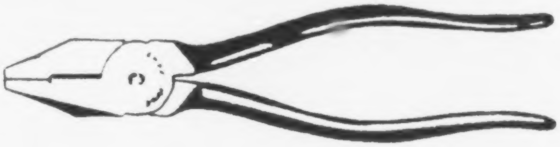
b. **Diagonal cutters** — Used for cutting small diameter wire, especially the wire used in gas metal arc welding



c. **Needle nose** — Used for cleaning cups and nozzles, for cutting small diameter wire, holding and bonding, and for general work around gas tungsten arc welding

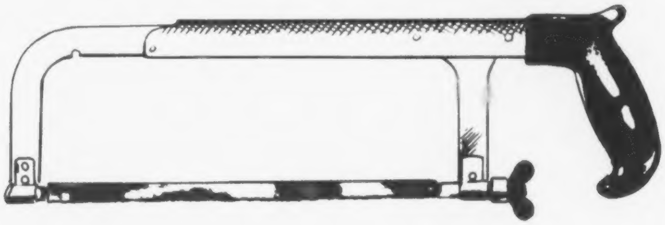


d. **Lineman's (side cutters)** — Used to cut larger diameter wire, for holding, and for general work around submerged arc welding



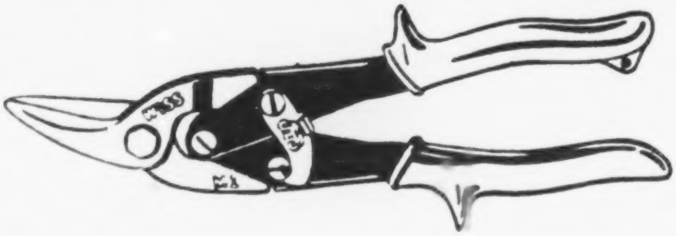
15. **Manual cutting and shaping tools and their uses**

a. **Hacksaw** — Used to manually cut or separate metal

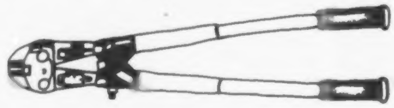


Information Sheet

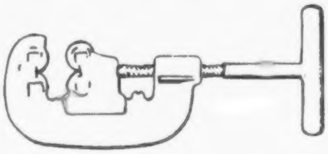
b. **Straight-cut snips** — Used to cut straight lines or curves on light-gauge metal



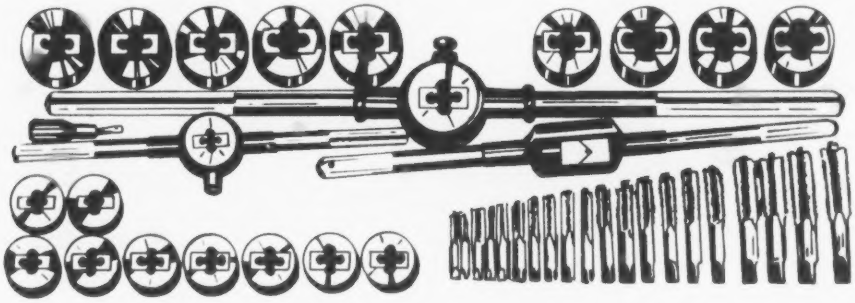
c. **Bolt cutters** — Used to cut small diameter nuts, bolts, rod, and chain



d. **Pipe cutters** — Used for cutting small-diameter pipe or tubing



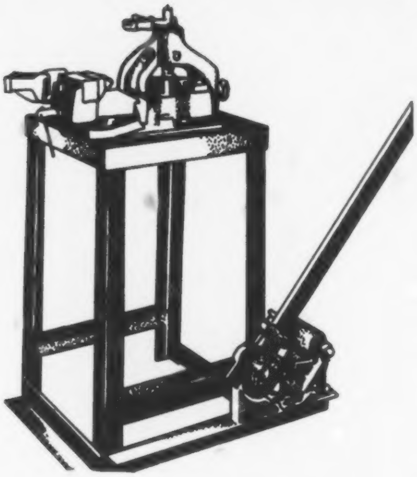
e. **Tap and die sets** — Used to cut inside threads (taps) in metal or to cut outside threads (dies) on pipe or other round stock



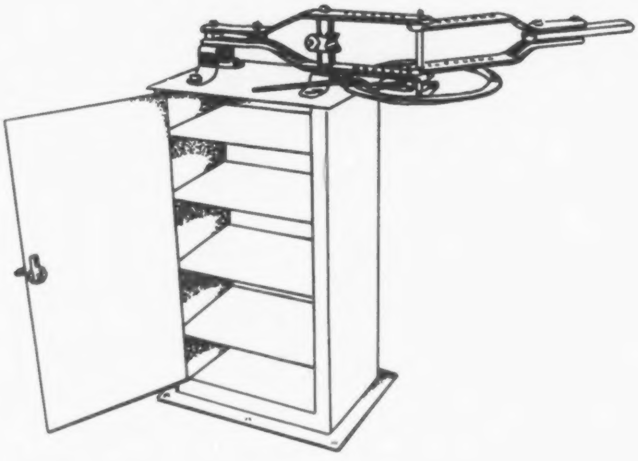
Information Sheet

16. Manually-operated shop tools and their characteristics and uses

a. **Angle iron cutter, notcher, and bender** — Used to cut, notch, and bend angle iron

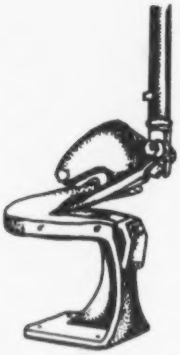


b. **Hossfeld bender** — Used to bend, form, and shape pipe, tubing, angle iron, flat bars, and straps

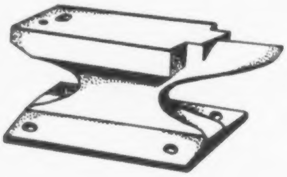


Information Sheet

c. **Beverly shear** — Lever operated bench tool that makes distortion free cuts in straight or curved patterns on light to heavy metals

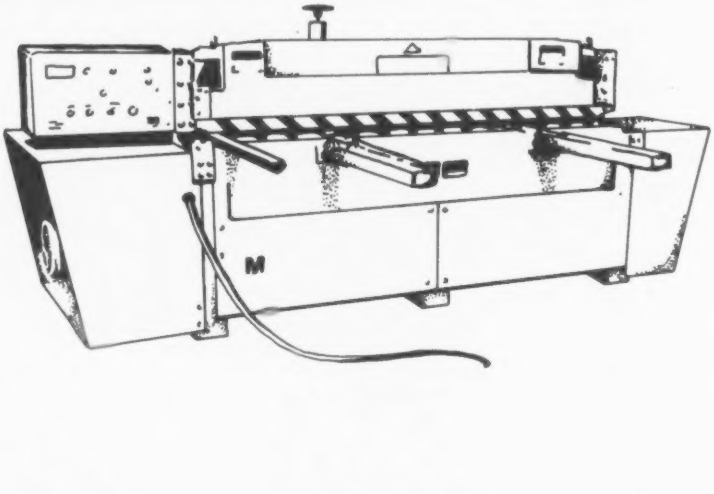


d. **Anvil** — An iron or steel block with both flat and curved surfaces for shaping metals that are hammered or peened against it



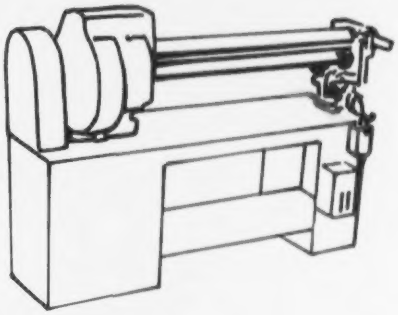
17. **Power equipment and its characteristics and uses**

a. **Power shear** — Uses mechanical, hydraulic, or pneumatic power to cut all gauges of metal

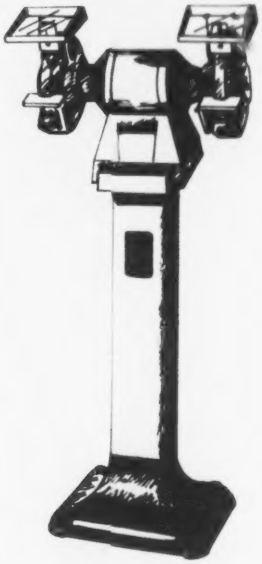


Information Sheet

b. **Power roll** — Used to shape both plate and structural metals into rounded forms

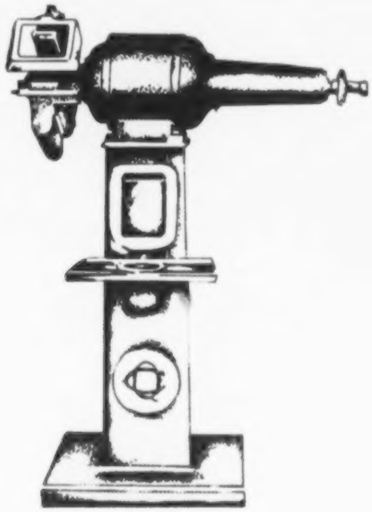


c. **Pedestal grinder** — Used for grinding all forms of metal

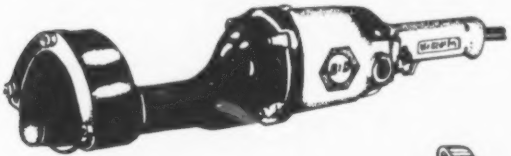


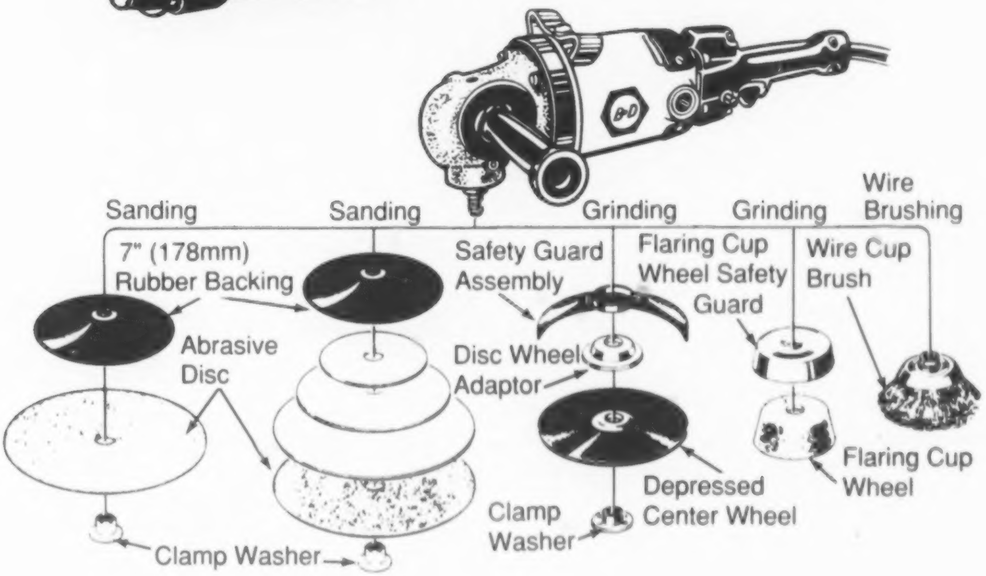
Information Sheet

d. **Pedestal buffer** — Used to polish or buff metals with wire, brush, or cloth wheels



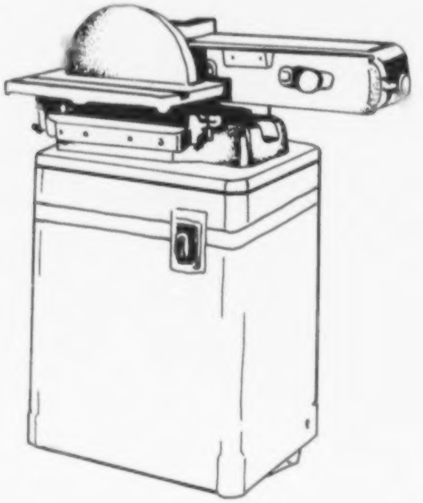
e. **Angle and straight grinders** — Generally used with attachments for cleaning joints before or after a welding process



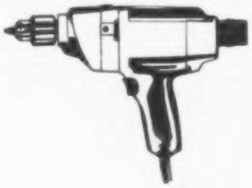

Sanding
Sanding
Grinding
Grinding
Wire Brushing
7" (178mm) Rubber Backing
Safety Guard Assembly
Flaring Cup Wheel Safety Guard
Wire Cup Brush
Abrasive Disc
Disc Wheel Adaptor
Depressed Center Wheel
Flaring Cup Wheel
Clamp Washer
Clamp Washer

Information Sheet

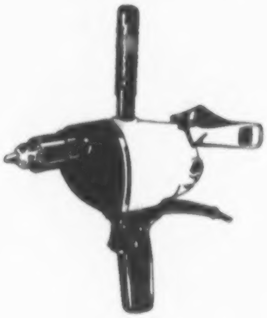
f. **Belt and disc sander** — Used to grind or sand flat metal surfaces



g. **Hand drill** — Generally used for light drilling jobs; designed with variable reversible speed in ¼", ⅜", and ½" sizes

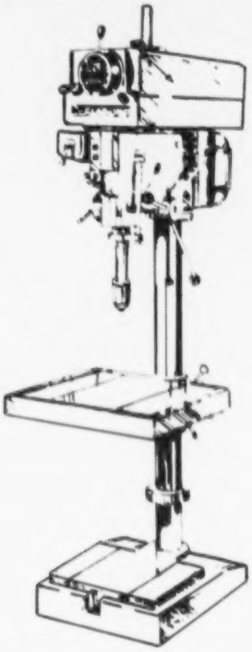


h. **Heavy duty hand drill** — Generally used for drilling thick materials; designed with variable or reversible speed in ½", ¾", and 1¼" sizes

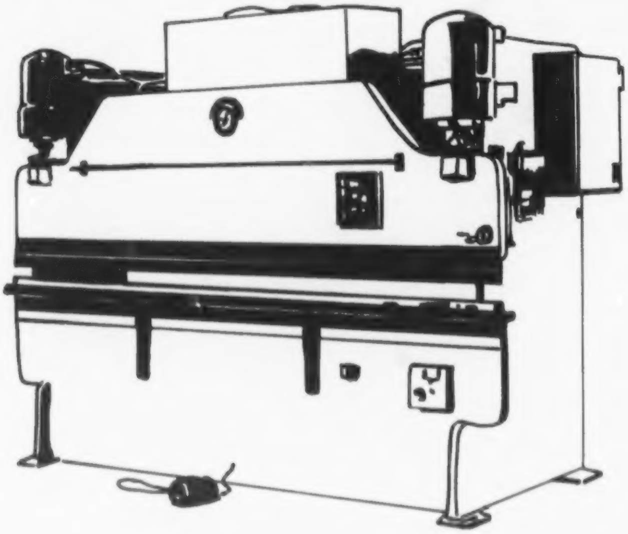


Information Sheet

i. **Drill press** — Used for drilling holes in several pieces of metal at one time or drilling single holes in heavier metals



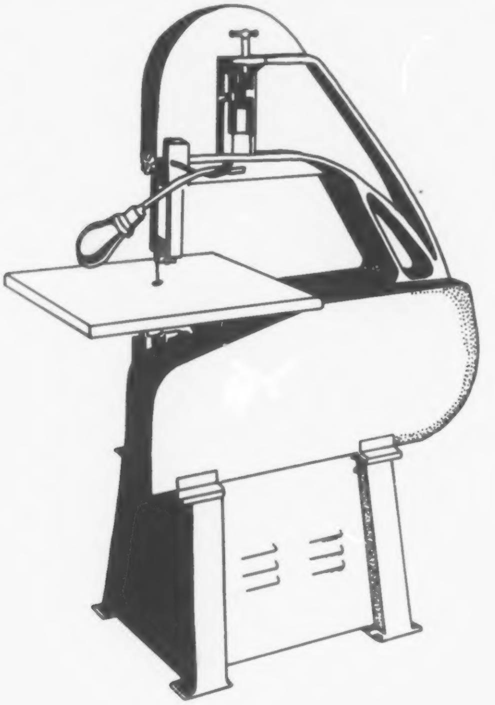
j. **Press brake** — Used with different dies and punches to press metal into a desired shape



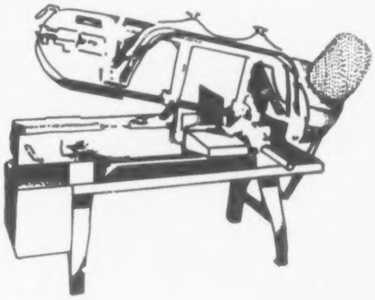
Information Sheet

18. Power saws and their characteristics and uses

a. **Vertical band saw** — Used with a continuous cutting blade for cutting mild steel



b. **Horizontal band saw** — Used with a continuous cutting blade to cut any length or type of metal



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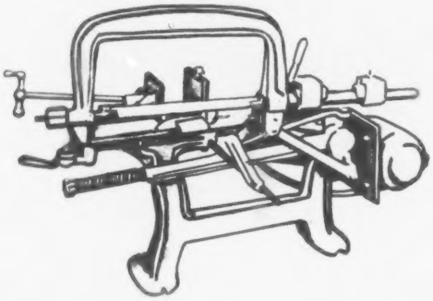
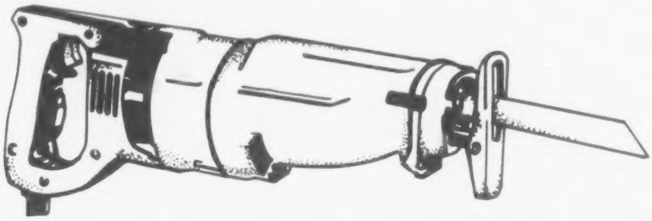
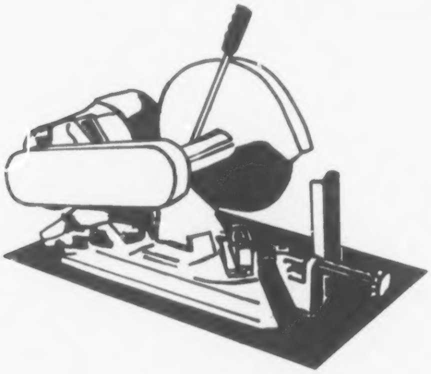
c. **Power hacksaw** — Used with a reciprocating blade to cut any length or type of metal



d. **Reciprocating saw** — Used like a key-hole saw with various types of blades to cut wood, metal, plastic, and even heavy steel



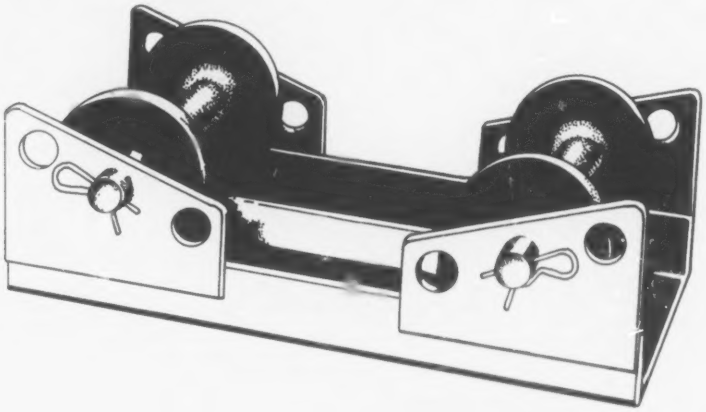
e. **Cut-off saw** — Used to cut heavier metal at different angles or in straight cuts



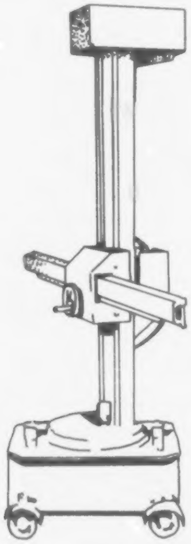
Information Sheet

19. Positioning equipment and its characteristics and uses

a. **Turning rolls** — Used in production or with automatic equipment that requires pipes or round objects to be rolled

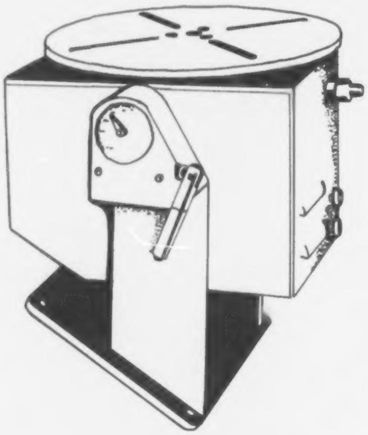


b. **Manipulators** — Used to control and position welding equipment on automatic positioners or turning rolls in production shops with automatic welding processes



Information Sheet

c. **Positioners** — Used to secure and position objects being welded; can turn or rotate an object at a preset speed or can be controlled manually by an operator



20. **Rules for hand tool safety**

    a. Never use a screwdriver as a prying tool.

    b. Never use pliers to loosen or tighten nuts and bolts.

    c. Never use any tool with a loose handle or defective part.

    d. When using a screwdriver, support the work on a bench or against a solid surface.

    e. When using a wrench, pull it toward yourself to prevent smashing your hand if the wrench should slip.

    f. Never use a file without a handle.

    g. Secure small parts or objects before working on them with hand tools.

    h. Never strike the mushroomed head of a punch or chisel.

21. **Basic rules for safe use of power tools and equipment**

    a. Do not use power tools until you have been instructed how to safely use them, and have permission from your instructor.

    b. Check electrical cords and plugs before using electrical power tools, and check lines and connections before using air-operated tools.

    c. When working with a drill press, always clamp the workpiece in place or it will spin with the drill bit.

Information Sheet

d. Make sure shields and guards are securely in place before using power equipment.

e. Avoid walking into restricted safety zones marked off around power equipment.

f. When using extension cords with power equipment, make sure they are grounded and free of breaks or frays.

g. Do not wear loose or frayed clothing around rotating equipment.

h. Pay attention to safety signs and warning tags.

i. Know emergency shut-down procedures for all power equipment.

j. Keep tools clean and dry.

22. Rules for tool and equipment maintenance

a. The number one rule for maintaining a tool or a piece of equipment is to use it only for its intended purpose.

b. Tag and report any tool or piece of equipment suspected of being faulty.

c. Record the type of service and date information placed on lubrication and maintenance schedules.

d. Always disconnect the power supply when performing maintenance on power tools and equipment.

e. Check tool rests on pedestal grinders daily.

f. Check grinding wheels daily and dress as needed.

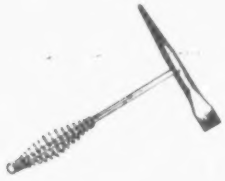
g. Check oil pressure on shears before using them.

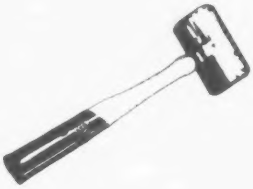
Welding Tools and Equipment
Unit 3

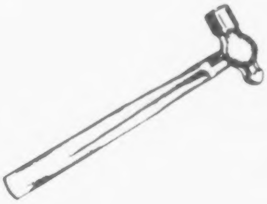
Assignment Sheet 1—Identify Basic Hand Tools

Evaluation criteria	Rating
Number properly identified	______

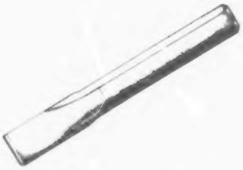
Directions: Write the name of the hand tool below its illustration.

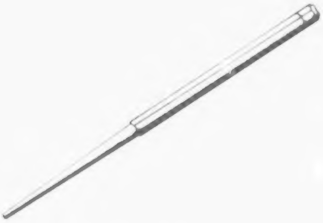


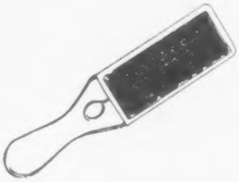




a. ______________________ b. ______________________ c. ______________________

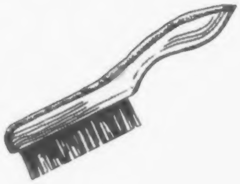




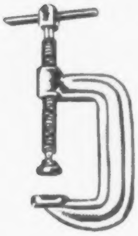


d. ______________________ e. ______________________ f. ______________________

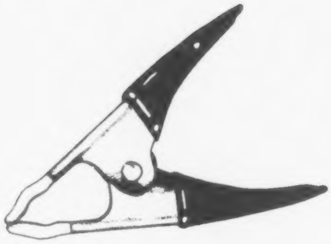
Assignment Sheet 1



g. ____________________



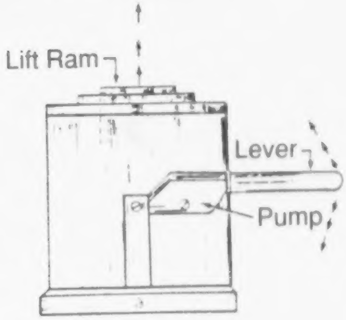
h. ____________________



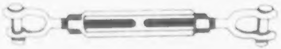
i. ____________________

j. ____________________

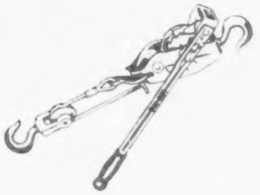
k. ____________________


Lift Ram
Lever
Pump

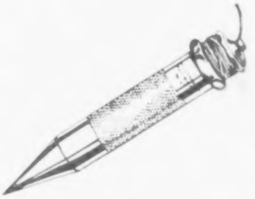
l. ____________________



m. ____________________

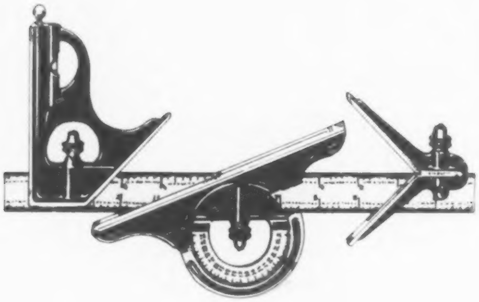


n. ____________________



o. ____________________

Assignment Sheet 1



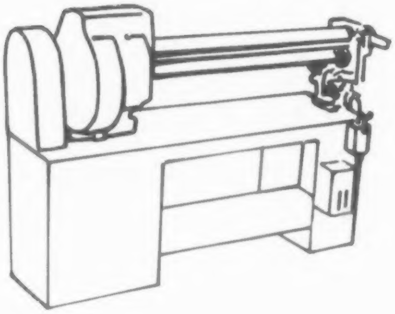
p. ______________________

Welding Tools and Equipment
Unit 3

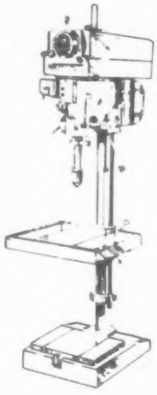
Assignment Sheet 2—Identify Basic Power Tools and Equipment

Evaluation criteria	Rating
Number properly identified	______

Directions: Write the name of the power tool or piece of power equipment below its illustration.

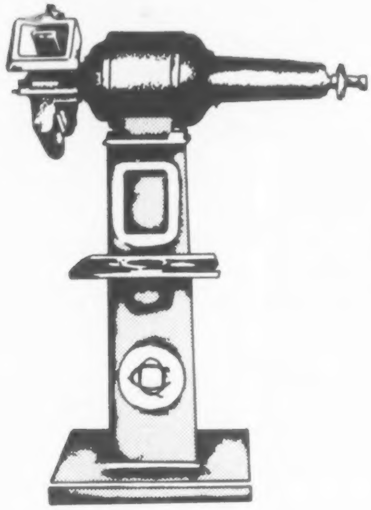


a. ________________________________

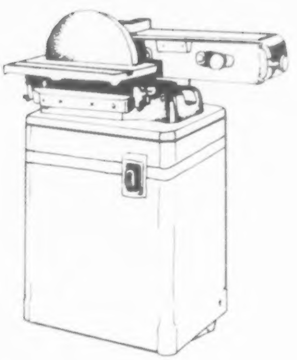


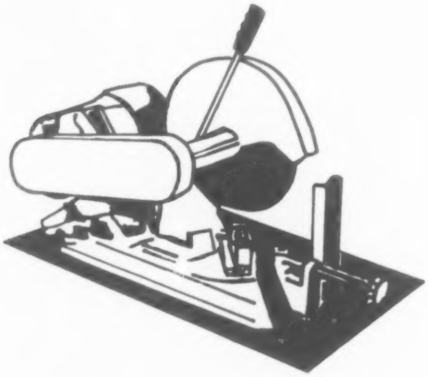
b. ________________________________

Assignment Sheet 2



c. ______________________________

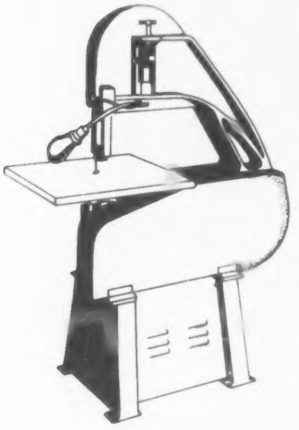


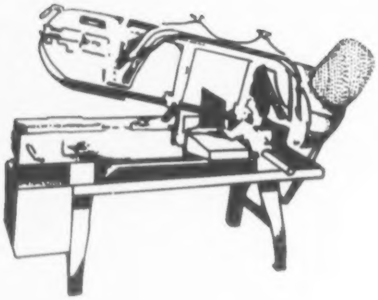


d. ______________________________

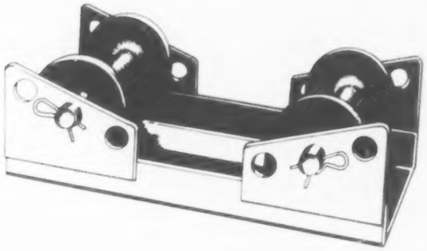
e. ______________________________

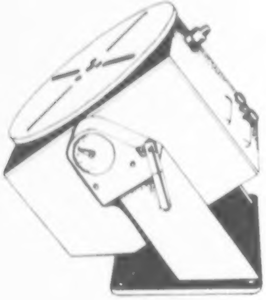
Assignment Sheet 2





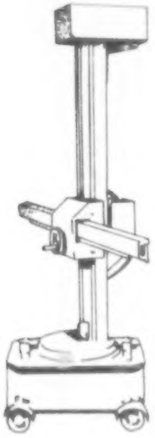
f. ______________________________ g. ______________________________





h. ______________________________ i. ______________________________

Assignment Sheet 2



j. ______________________________

Basic Metals and Metallurgy
Unit 4

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify metals by appearance, color, and corrosion characteristics, and conduct magnet tests, spark tests, and chisel tests to identify common metals used for welding. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic metals and metallurgy with their correct definitions.
2. Select true statements about advantages of proper metal identification.
3. Match basic metals, alloys, and properties with their definitions.
4. Select true statements about metal identification tests and their characteristics.
5. Match mechanical properties of metals with their characteristics.
6. Match types of mechanical strengths with their characteristics.
7. Select true statements about physical properties of metals and their characteristics.
8. Solve problems about steel identification systems and their characterisitcs.
9. Complete a chart of carbon steel classifications, characteristics, and typical uses.
10. Match principal steel alloys with their uses.
11. Complete a chart of alloy steel classifications, characteristics, and typical uses.
12. Complete a chart of iron classifications, characteristics, and typical uses.

Objective Sheet

13. Complete statements about guidelines for identifying metals by color and characteristics.

14. Select true statements about aluminum, its characteristics, and uses.

15. Complete statements about basics of the *commercial* system for identifying aluminum.

16. Select true statements about the 1XXX group commercial identification system.

17. Select true statements about the 2XXX plus group commercial identification system.

18. Solve problems about other elements of commercial aluminum identification and their meanings.

19. Complete definitions of aluminum quality designations and their meanings.

20. Arrange in order the steps in using the commercial system to identify aluminum.

21. Match other nonferrous metals with their typical uses.

22. Select true statements about guidelines of testing properties of metals.

23. Select true statements about equipment requirements for spark testing.

24. Complete statements about guidelines for spark testing.

25. Complete statements about characteristics of residual stresses.

26. Select true statements about causes of residual stresses and distortion.

27. Select true statements about guidelines for controlling expansion and contraction.

28. Identify routes for heat expansion in basic welds.

29. Identify results of longitudinal and transverse stress in basic welds.

30. Complete statements about heat applications and their uses in weld quality control.

31. Select true statements about guidelines for preheating in special conditions.

32. Complete statements about methods of preheating and postheating and their applications.

Objective Sheet

33. Match torch preheating techniques with their applications.

34. Match types of steels with their recommended preheat temperatures.

35. Match temperature-sensing devices with their uses.

36. Identify methods for controlling distortion with the welding process.

37. Select true statements about guidelines for controlling distortion with mechanical means.

38. Match methods for controlling distortion with restraining devices with their applications.

39. Identify selected metals by appearance, color, and corrosion characteristics. (Assignment Sheet 1)

40. Conduct magnet tests to identify common metals used for welding. (Job Sheet 1)

41. Conduct chisel tests to identify common metals used for welding. (Job Sheet 2)

42. Conduct spark tests to identify common metals used for welding. (Job Sheet 3)

Basic Metals and Metallurgy
Unit 4

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TMs 1 and 2—Spark Test Characteristics (Objective 24)
   TM 3—Metal Melting Points and Other Temperatures (Objective 5, 6, 7, and 8)
   TM 4—Heating Ranges for Ferrous Metals (For use with Teacher Supplement 1)
   TM 5—Aluminum Hardness and Tempering Designations (Objective 18)

5. Obtain films, videotapes and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment and job sheets. Review criteria for evaluation of these activities.

Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest and required.

Teaching Suggestions

Note: Skill areas appearing in bold face type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skill areas have been adapted by MAVCC.

1. This is a long unit of instruction. Teach the unit in related segments, and break the test up to reflect the segments so students will not be faced with an extremely long test. Objective 25 through 30 concern themselves with residual stresses and distortion and how to control them. Teach these objectives together and provide adequate demonstration of items related to distortion control. Ideally, this part of the unit should be integrated with the teaching of Oxyacetylene Welding or Shielded Metal Arc Welding. In other words, provide students the opportunity to work with distortion control as it really happens on the job. Distortion control should be on students minds in all welding activities. Skill areas: **learning to learn**.

2. When teaching Objective 7, demonstrate thermal conductivity as it is shown in the objective. Have students assist with the demonstration so they will become personally involved. Skill areas: **foundation skills** and **science**.

3. Prepare a testing demonstration for Objective 22. If you have a Brinell or Rockwell tester, use it to demonstrate a hardness test. Prepare test coupons properly notched to demonstrate the Izod and Charpy tests. Have students help with the testing. Skill areas: **foundation skills** and **science**.

Suggested Activities

4. Demonstrate the equipment required for spark testing as it is outlined in Objective 23 and Job Sheet 3. Be sure to stress proper grinding wheel rpm, and show students manufacturer's information about rpm adjustment for a stationary or a disc grinder. Demonstrate how to clean a grinding wheel with a wire brush. Next, demonstrate the spark testing procedure outlined in Objective 24. Have students help by getting involved with color identification and stream identification. Wait until last to demonstrate a nonferrous metal, and then grind a piece of ferrous metal long enough to clean the grinding wheel so it will be ready for use in Job Sheet 3. If you do grind aluminum, use a grinding wheel or disc designed to grind aluminum. Skill areas: **foundation skills** and **science**.

Resources Used in Developing This Unit

1. Fortney, Clarence and Mike Gregory. *Introduction to Welding*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

2. *The Procedure Handbook of Arc Welding, Twelfth Edition*. Cleveland, OH: The Lincoln Electric Company, 1973.

3. *New Lessons in Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1981.

4. *Welding Kaiser Aluminum, First Edition*. Oakland, CA: Kaiser Aluminum and Chemical Sales, Inc., 1967.

5. Repp, Victor E., Willar J. McCarthy and Oswald A. Ludwig. *Metalwork Technology and Practice, Seventh Edition*. Bloomington, IL: McKnight Publishing Company. 1982.

6. Neely, John E. *Practical Metallurgy and Materials of Industry*. New York: John Wiley & Sons, Inc., 1979.

7. *Welding Handbook, Seventh Edition, Volume 4, Metals and Their Weldability*. Miami, FL: American Welding Society, 1982.

8. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami. FL: American Welding Society, 1987.

9. O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 2, Welding Processes*. Miami, FL: American Welding Society, 1991.

Suggested Activities

Suggested Supplemental Resource

An excellent video titled *Prevention and Control of Distortion* is available from the Lincoln Electric Company. The 20-minute production was made especially for Lincoln by Walt Disney Studios. The video features an animated cartoon character called Mr. Shrink. It is a color production, available in VHS format. The video may be ordered by title or by number, which is ED-211. The video costs $30, and prepaid orders should be sent to:

Book Department
The Lincoln Electric Company
22801 St. Clair Avenue
Cleveland, OH 44117

For further information, call 216-383-2211.

Basic Metals and Metallurgy
Unit 4

Answers to Assignment Sheet

Evaluated according to written criteria.

Basic Metals and Metallurgy
Unit 4

Answers to Written Test

1. a. 3
b. 7
c. 9
d. 11
e. 4
f. 1
g. 2
h. 6
i. 8
j. 12
k. 10
l. 5

2. b

3. a. 3
b. 6
c. 5
d. 2
e. 7
f. 1
g. 4

4. a, b, c, f

5. a. 2
b. 4
c. 6
d. 8
e. 10
f. 9
g. 7
h. 5
i. 3
j. 1

6. a. 2
b. 4
c. 1
d. 3

7. a, b, e

8. a. 2
b. 2
c. 2

9. a. 2
b. 4
c. 1
d. 3

10. a. 3
b. 4
c. 1
d. 2
e. 6
f. 5

Answers to Written Test

11. a. 4 e. 8 i. 7
b. 6 f. 12 j. 3
c. 2 g. 11 k. 5
d. 10 h. 1 l. 9

12. a. 2
b. 4
c. 1
d. 3

13. a. Rust
b. Dull metallic
c. Some
d. In almost any environment
e. Rapidly
f. Has high corrosion resistance
g. Resists corrosion, but will tarnish
h. Resists corrosion

14. b, d, e, f

15. a. 1. 99%
2. Copper
3. Manganese
4. Silicon
5. Magnesium
6. Silicon and magnesium in approximate proportion as the principal alloying elements
7. Zinc

b. Four-digit; four-digit

16. b

17. a, b

18. a. H
b. T

19. a. Aircraft
b. Commercial
c. High tensile

20. a. 3 d. 4
b. 5 e. 2
c. 1

Answers to Written Test

21. a. 5
    b. 7
    c. 9
    d. 1
    e. 3
    f. 8
    g. 6
    h. 10
    i. 2
    j. 4

22. a, c

23. c, d

24. a.
    (1) b
    (2) a
    (3) a
    (4) a
    (5) b

    b.
    (1) Red
    (2) Straw
    (3) White
    (4) Orange

    c.
    (1) No volume
    (2) Small; small
    (3) Moderately large
    (4) Large
    (5) Moderate to large

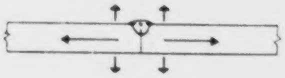
    d.
    (1) Low-carbon
    (2) High-carbon
    (3) Varying

25. a. Undesirable element
    b. Shrinkage
    c. Base metals

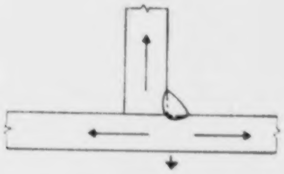
26. a, b

27. a, b, c, e, f, g

28. a.



b.



200

Answers to Written Test

29. a. 2
    b. 2
    c. 2
    d. 2

30. a. Hardening
    b. Required temperature
    c. In the weldment and the base metal

31. a, b, e

32. a. Small
    b. Bulky
    c. Long or wide
    d. General service
    e. The same size as
    f. Large parts

33. a. 3
    b. 1
    c. 2

34. a. 2
    b. 1
    c. 3

35. a. 2
    b. 3
    c. 1

36. a. 2
    b. 1
    c. 1
    d. 3
    e. 1
    f. 1

37. a, c, d

38. a. 2
    b. 3
    c. 4
    d. 1

Basic Metals and Metallurgy
Unit 4

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

______a. The science that explains the properties, behavior, and internal structure of metals

______b. Metals added in making a brazed, welded, or soldered joint

______c. Application of heat to a base metal before welding or cutting

______d. Maintenance of heat to a base metal and weld passes during a welding process

______e. Application of heat to a weld and/or a base metal after a welding operation to promote a slower cooling rate and relieve stresses in the base metal and the weldment

______f. Assembly of two or more metal parts with welding

______g. Two or more metals that have similar properties that can readily be joined

______h. American Iron and Steel Institute

______i. Society of Automotive Engineers

______j. The process of forcing a metal through a special die to give it shape and length

______k. Aluminum Association

______l. A metal that has had its strength, hardness, and brittleness increased with or without heating

1. Weldment
2. Compatibility
3. Metallurgy
4. Postheating
5. Strain-hardened
6. AISI
7. Filler metals
8. SAE
9. Preheating
10. AA
11. Interpass temperature
12. Extruding

Written Test

2. Select true statements about advantages of proper metal identification. Place an "X" beside each true statement.

______a. Proper metal identification helps determine how many different welding processes would be possible for a particular metal.

______b. Proper metal identification helps establish requirements for preheating, interpass heating, and postheating.

______c. Proper metal identification helps establish what metals are incompatible so that proper filler metals can be selected.

3. Match basic metals, alloys, and properties with their definitions. Place the appropriate reference number in the proper blank.

______a. Metals that contain iron as the major element

______b. Metals that contain no iron or an extremely small amount of iron

______c. A single element dissolved together with a metal or metals in a solid solution

______d. Steels formed by adding one or more additional elements to give the steels special properties

______e. The measure of how materials behave under applied loads

______f. Properties such as melting point or thermal conductivity which are affected when metals are subjected to heat

______g. Properties which involve corrosion, oxidation, and reduction

1. Physical properties
2. Alloy steels
3. Ferrous metals
4. Chemical properties
5. Alloys
6. Nonferrous metals
7. Mechanical properties

4. Select true statements about metal identification tests and their characteristics. Place an "X" beside each true statement.

______a. Appearance—Surface color reveals the presence of oxidation; when exposed to weather, some metals will rust, others tarnish, and others remain oxidation free.

______b. Chemical—Certain chemicals or acids applied to metals cause different reactions in different metals.

______c. Chisel—When chipped with a chisel, certain metals produce a continuous chip, others break up into small particles, and others cannot be chipped.

Written Test

______d. File—Ferrous metals are usually easy to file, but nonferrous metals are difficult to file.

______e. Magnet—A magnet sticks to nonferrous metals, but it will not stick to ferrous metals.

______f. Sound—When struck with a hammer, most metals have a characteristic ring or lack of it.

______g. Spark—Nonferrous metals have definite spark patterns, but ferrous metals have no spark pattern.

5. Match mechanical properties of metals with their characteristics. Place the number of the characteristic in the appropriate blank.

______a. The capacity of metal to resist penetration, abrasion, and deformation

______b. The capacity of a metal to resist changing its shape or size when exposed to external forces

______c. The capacity of a metal to be permanently stretched without breaking

______d. The capacity of a metal to be hammered or rolled into shape without breaking

______e. The tendency of certain metals to break or fracture if bent or struck sharply

______f. The capacity of a metal to return to its original size and shape when the force that changed it is removed

______g. The incapacity of a metal to return to its original size and shape when the force that changed it is removed

______h. The tendency of some metals to break or fracture under a repeated or sustained load

______i. The capacity of a metal to absorb without failure the impact of a load applied rapidly

______j. The measure of ductility of material measured in a tension test

1. Elongation
2. Hardness
3. Impact resistance
4. Strength
5. Fatigue
6. Ductility
7. Elastic limit
8. Malleability
9. Elasticity
10. Brittleness

Written Test

6. Match types of mechanical strengths with their characteristics. Place the number of the characteristic in the appropriate blank.

______a. The capacity of a metal to resist being pulled apart

______b. The capacity of a metal to resist being pushed or crushed together

______c. The capacity of a metal to withstand a sustained load across its cross section

______d. The capacity of a metal to resist twisting forces

1. Shear strength
2. Tensile strength
3. Torsional strength
4. Compressive strength

7. Select true statements about physical properties of metals and their characteristics. Place an "X" beside each true statement.

______a. Density is the weight of a given piece of metal in relation to a unit size.

______b. Electrical conductivity is the capacity of a metal to conduct electrical current.

______c. Thermal conductivity is the capacity of a metal to resist-heat.

______d. Thermal expansion is the tendency of metals to expand when heated or cooled.

______e. Melting point is the point to which a metal must be heated before it will melt.

8. Solve problems about steel identification systems and their characteristics. Circle the number of the information that best solves the following problems.

a. A shipment of steel has just arrived at a welding shop. All the steel has the identification SAE 1010. What steel identification system is on the steel, and what does it mean?

(1) The Society of Automotive Engineers' ID system indicates that it is a stainless steel.
(2) The Society of Automotive Engineers' ID system indicates a low-carbon steel with a 10% carbon alloy.
(3) The Id system is unimportant because the steel has less than 25% carbon alloy.

b. A shipment of steel has just arrived at a welding shop. Some of the steel has AISI C 1020 stamped on it, and the rest of the steel has a green bar painted on one end with four numbers painted in yellow. What steel identification system is on the steel, and what does it mean?

(1) The ID system is from the American Iron and Steel Institute and indicates a low-carbon steel.
(2) There are actually two ID systems on the steel. The AISI number indicates an open-hearth carbon steel product with 20% carbon alloy, and the color coding means to check the manufacturer's color code guide.
(3) The AISI number indicates a low-carbon steel with only 2% carbon alloy, and the color code indicates the same.

c. A shipment of steel has just arrived at a welding shop. All the steel is stamped S99995. What steel identification system is on the steel, and what does it mean?

(1) It is an AISI identification system, and it means that it is a high-carbon steel.
(2) It is a Unified Numbering System identification, and it means the product is stainless steel.
(3) The S indicates "steel" and the numbers indicate a very high carbon content.

9. Complete a chart of carbon steel classifications, characteristics, and typical uses. Place the number of the typical uses in the appropriate blank.

Classification	Characteristics	Typical Uses
Low carbon	0.07% to 0.15% carbon	a. ____________
Mild steel	0.15% to 0.30% carbon	b. ____________
Medium carbon	0.30% to 0.50% carbon	c. ____________
High carbon	0.50% to 1.00% carbon	d. ____________

1. Axles, shafts, machine bolts, boilers, hammers, and sledges
2. Nails, iron bars and rods, auto bodies, and pipes
3. Screwdrivers, crow bars, axes, springs, razor blades, and fine cutters
4. Gears, shafts, bolts, metal frames, angles, and channels

Written Test

10. Match principal steel alloys with their uses. Place the number of the alloy in the appropriate blank.

_______a. Used to make steels hard and strong

_______b. Used to make steels that will remain hard when subjected to very high temperatures

_______c. Used to make special steels with improved ductility while maintaining strength and toughness and a high resistance to corrosion and shock

_______d. Used to make special steels that are hard and brittle

_______e. Produces the greatest hardening effect of any element except carbon

_______f. Increases tensile strength and hardness, as well as resistance to corrosion and oxidation

1. Nickel
2. Silicon
3. Carbon
4. Cobalt
5. Chromium
6. Molybdenum

Written Test

11. Complete a chart of alloy steel classifications, characteristics, and typical uses. Place the number of the alloy steel in the appropriate blank.

Classification	Characteristics	Typical Uses
a. ______	Strong and hard, resists corrosion, withstands shocks, vibration, and wear	Wire cables, railroad and car axles, and steel rails
b. ______	Fine grain, tough and strong, resists corrosion, shocks, and scratches	Auto bearings and safes
c. ______	Does not corrode, has a bright, silvery finish that looks good	Sinks, tables, and food service items subject to high standards of cleanliness
d. ______	Hard and strong	Auto gears, springs, axles, and armor plate
e. ______	Tough and strong, can resist strain, shock, and hammering	Jaws of rock crushers, chains, gears, and safes
f. ______	Tough and strong, resists heat and impact wear	Auto parts, high-grade machinery, and roller bearings
g. ______	Hard, fine grained, and resists heat	High-speed metal cutting tools
h. ______	Holds magnetism well	Electrical measuring instruments
i. ______	Hardest man-made metal	Cutting tools and dies
j. ______	Tough, but lightweight, fine grained, and resists shock	Auto axles, gears, and springs
k. ______	Extremely hard	Heavy cutting tools
l. ______	Self-hardening steel	Cutting tools, taps, and drills

1. Tungsten steel (magnet steel)
2. High chromium steel (stainless steel)
3. Vanadium steel
4. Nickel steel
5. Satellite steel
6. Chromium steel
7. Tungsten steel (tungsten carbide)
8. Manganese steel
9. High-speed steel
10. Chrome-nickel steel
11. Tungsten steel
12. Molybdenum steel

12. Complete a chart of iron classifications, characteristics, and typical uses. Place the number of the characteristics in the appropriate blank.

Classification	Characteristics	Typical Uses
Wrought iron	a. ______	Rivets, bolts, nails, horseshoes, and ornamental iron
Gray cast iron	b. ______	Large pipes, stoves, water hydrants, and machinery frames
White cast iron	c. ______	Machine parts subjected to extreme wear or abrasion
Malleable cast iron	d. ______	Farm tools, implement parts, and railroad equipment

1. Very hard and brittle
2. Resists corrosion, withstands shock, is malleable and easy to bend hot or cold
3. Tougher and more impact resistant than other cast irons
4. Relatively inexpensive, high compressive strength, but low tensile strength and brittle

13. Complete statements about guidelines for identifying metals by color and characteristics. Circle the material that best completes each of the following statements.

    a. For low, medium, and high-carbon steels, look for new stock to be dark gray; these grades of steel (**rust**) (**tarnish**) with age, and rust rapidly when stored outside.

    b. For manganese steels, look for a (**dull metallic**) (**glossy**) surface on new stock; these steels rust with age, and rust rapidly when stored outside.

    c. For stainless steels, look for bright, silvery-smooth surfaces; (**all**) (**some**) grades of stainless rust with age and other grades tarnish.

    d. For cast iron, look for a dull, gray color with evidence of the sand mold on new stock; cast irons rust rapidly (**in almost any environment**) (**when left outside**).

    e. For wrought iron, look for new stock to be light gray and smooth; wrought irons rust (**rapidly**) (**slowly**) in almost any environment.

    f. For aluminum, look for new stock to have a silvery-white, smooth surface; this light-weight metal (**has high corrosion resistance**) (**has medium corrosion resistance**).

g. For copper, look for a reddish-brown, dull finish on new stock; copper (**resists corrosion, but it will tarnish**) (**will corrode and tarnish**).

h. For nickel, look for a hard, white finish; nickel (**resists corrosion**) (**is subject to corrosion**).

14. Select true statements about aluminum, its characteristics and uses. Place an "X" beside each true statement.

______a. Aluminum is most used and most expensive of the nonferrous metals.

______b. Aluminum is a silvery-white metal with a brilliant surface beauty that resists corrosion and is maintenance free.

______c. Pure aluminum is very hard and difficult to use, so it is usually combined with an alloy to change its characteristics.

______d. Aluminum is a good conductor of electricity, an excellent thermal reflector when it is polished, and a good thermal conductor in other forms.

______e. Aluminum is both malleable and ductile and can easily be formed into shapes or into wire.

______f. Aluminum is available in sheets, plates, bars, wires, pipes, tubes, and a great number of extruded forms.

15. Complete statements about basics of the commercial system for identifying aluminum. Circle the material that best completes each statement.

a. The commercial system identifies aluminum by groups:

(1) The 1XXX group indicates aluminum of (**90%**) (**99%**) or higher purity.
(2) The 2XXX group indicates aluminum with (**copper**) (**nickel**) as the principal alloying element.
(3) The 3XXX group indicates aluminum with (**copper**) (**manganese**) as the principal alloying element.
(4) The 4XXX group indicates aluminum with (**magnesium**) (**silicon**) as the principal alloying element.
(5) The 5XXX group indicates aluminum with (**silicon**) (**magnesium**) as the principal alloying element.
(6) The 6XXX group indicates aluminum with (**silicon and magnesium in approximate proportions**) (**titanium**) as the principal alloying element.
(7) The 7XXX group indicates aluminum with (**zinc**) (**chromium**) as the principal alloying element.

b. In the commercial identification system. there is a (**six-digit**) (**four-digit**) ID system especially for group 1XXX, and another (**three-digit**) (**four-digit**) ID system for the 2XXX plus group.

Written Test

16. Select true statements about the 1XXX group commercial identification system. Place an "X" beside each true statement.

    _______a. In the 1XXX group four-digit code, the first digit indicates a minimum of 90% aluminum.

    _______b. The second digit indicates the degree of special control of impurities, with 0 indicating no special control and 9 indicating the highest special control.

    _______c. The last two digits have no special significance except to the manufacturer.

17. Select true statements about the 2XXX plus group commercial identification system. Place an "X" beside each true statement.

    _______a. In the 2XXX plus four-digit code, the first digit indicates the major alloying element in the aluminum.

    _______b. The second digit indicates the amount of modification to the alloy, with 0 indicating no modification and 9 indicating the highest modification.

    _______c. The last two digits have no special significance except to the manufacturer.

18. Solve problems about other elements of commercial aluminum identification and their meanings. Circle the number of the best solution to each of the following problems.

    a. A worker sent to locate a strain hardened sheet of aluminum for a special job needs to look for what stamp on the sheet?

       (1) The letter O
       (2) The letter F
       (3) The letter H

    b. A worker sent to locate a thermally treated sheet of aluminum for a special job needs to look for what stamp on the sheet?

       (1) The letter H
       (2) The letter T
       (3) The letter O

Written Test

19. Complete definitions of aluminum quality designations and their meanings. Write the correct information in the appropriate blank.

    a. AQ—________________ quality

    b. CQ—________________ quality

    c. HTQ—________________ quality

20. Arrange in order the steps in using the commercial system to identify aluminum. Place a "1" beside the first step, and then list other steps in order.

    ______a. Determine the H or T designation.

    ______b. Determine the quality designation.

    ______c. Determine the number code series.

    ______d. Determine the degree of hardness.

    ______e. Determine the principal alloying element.

21. Match other nonferrous metals with their typical uses. Place the number of the nonferrous metal in the appropriate typical use blank.

    ______a. Used in electric and telephone wires and in industrial applications because it is the second best conductor of electricity; also alloyed with zinc or tin to make brass or bronze

    ______b. Used to galvanize iron and steel for protection from rust

    ______c. Used in everything from lawnmower engine blocks to space vehicles because it is lightweight

    ______d. Used primarily as an alloy to toughen steel

    1. Nickel
    2. Silver
    3. Titanium
    4. Tin
    5. Copper
    6. Gold
    7. Zinc
    8. Beryllium
    9. Magnesium
    10. Lead

______e. Used in supersonic aircraft because of its high heat resistance and capacity to withstand vibration; used in petrochemical applications because of its high corrosion resistance

______f. Used in the space program because of its light weight and high heat resistance

______g. Used for jewelry, coins, and coating electrical devices; usually alloyed with copper or nickel because it is too soft for general use

______h. Used in auto batteries and alloyed with tin to make solder

______i. Used in coins, jewelry, tableware, and in industrial applications because it is the best conductor of electricity

______j. Used for coating tin cans, and used as an alloy to make bronze, babbitt, pewter, and solder

22. Select true statements about guidelines for testing properties of metals. Place an "X" beside each true statement.

______a. To test for hardness, use a Brinnel hardness tester or a Rockwell tester.

______b. To test for weld strength, use a Brinnel tester.

______c. To test for impact resistance, use a Izod or a Charpy test with the specimen properly secured for accepting the test load impact.

______d. To test for alloys by type and amount, use a Rockwell tester.

Written Test

23. Select true statements about equipment requirements for spark testing. Place an "X" beside each true statement.

______a. Spark testing requires a stationary or portable grinder with a hard-grit grinding wheel.

______b. For spark testing with a stationary grinder, use an 8″ diameter grinding wheel with a turning rate of 5,000 rpm.

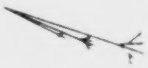
______c. For spark testing with a protable grinder, use a 7″ disc with a turning rate of 5,000 rpm.

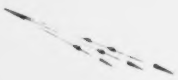
______d. Use a clean grinding wheel for spark testing, and use a wire brush if the grinding wheel needs cleaning.

24. Complete statements about guidelines for spark testing. Circle the material that best completes each of the following statements.

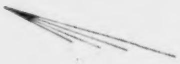
a. Learn to recognize the types of sparks produced by the metals you grind.

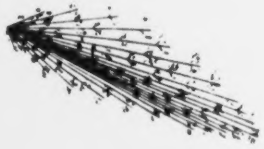
(1) An arrow looks like this:

a. 

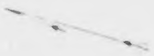
b. 

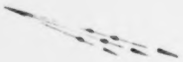
(2) A shaft looks like this:

a. 

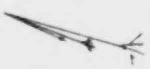
b. 

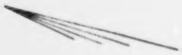
(3) A fork looks like this:

a. 

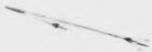
b. 

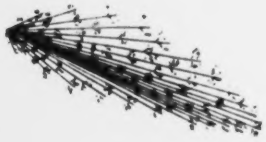
(4) A spring looks like this:

a. 

b. 

(5) A stream looks like this:

a. 

b. 

Written Test

b. Look for specific colors as sparks fly from the grinding wheel.

   (1) A (**red**) (**yellow**) color usually indicates cast iron.

   (2) A (**green**) (**straw**) color at the end of a stream also indicates cast iron.

   (3) A (**straw**) (**white**) color usually indicates low- or high-carbon steel.

   (4) An (**orange**) (**yellow**) color usually indicates chromium.

c. Evaluate the volume of sparks that fly from the grinding wheel.

   (1) Nonferrous metals produce (**a small volume**) (**no volume**).

   (2) Gray cast iron produces a (**medium**) (**small**) volume, and white cast iron produces a very (**thin**) (**small**) volume.

   (3) Low-carbon steel produces a (**large**) (**moderately large**) volume.

   (4) High-carbon steel produces a (**moderately large**) (**large**) volume.

   (5) Stainless steel produces a (**small to medium**) (**moderate to large**) volume, depending on the type and amount of alloy in the steel.

d. Note the distance the sparks fly from the grinding wheel.

   (1) (**Low-carbon**) (**High-carbon**) steels throw shafts that terminate in forks about 70 inches long.

   (2) (**Low-carbon**) (**High-carbon**) steels throw numerous sprigs that look like sparklers about 55 inches long.

   (3) Stainless and other alloy steels throw shafts and arrows at (**long**) (**varying**) distances, depending on the type and amount of alloy.

25. Complete statements about characteristics of residual stresses. Circle the material that best completes each of the following statements.

   a. Residual stresses are the (**basic elements**) (**undesirable elements**) of distortion left in a part or an assembly after a welding operation is completed.

   b. The forces and counterforces of residual stress can produce (**expansion**) (**shrinkage**), fractures, and other forms of distortion that make parts difficult or impossible to fit up.

   c. Residual stresses can produce in (**filler metals**) (**base metals**) structural and metallurgical changes so severe that a welded assembly could fail in service and damage property or injure people.

Written Test

26. Select true statements about causes of residual stresses and distortion. Place an "X" beside each true statement.

______a. In a welding process, filler metals and base metals expand uniformly in any direction if they are restricted, but if they are not restricted, they cannot expand uniformly.

______b. After a welding procedure, filler metals and base metals contract as they cool, and will assume their original shape if unrestricted, but if restricted, they will not contract uniformly.

______c. In a restricted weldment, the lack of uniformity in expansion and contraction means that residual stresses will vary with joint design, welding procedure, and metal type and thickness.

______d. Welding thick metals promotes residual stresses, and the thicker the metal, the more problems with residual stresses.

27. Select true statements about guidelines for controlling expansion and contraction. Place an "X" beside each true statement.

______a. Modify the joint design.

______b. Minimize the heat input by modifying the welding process.

______c. Select alternate filler metals or base metals.

______d. Peen the weld lightly to help it shrink.

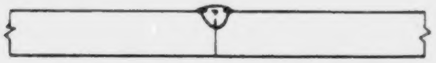
______e. Stress relieve by using a postweld heat treatment.

______f. Add thermal control by using preheating, interpass heating, postheating, or all three.

______g. Add mechanical control by using clamps, wedges, or mechanical jigs and fixtures.

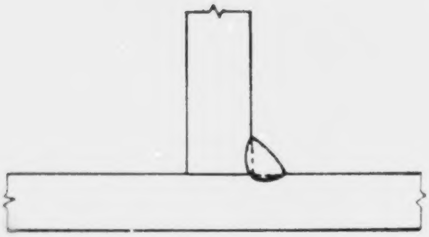
28. Identify routes for heat expansion in basic welds. Sketch arrows on the following illustrations to indicate the expansion routes.

a.



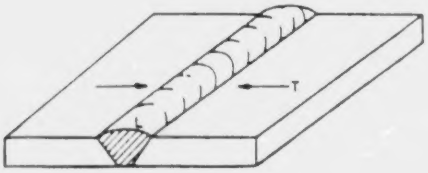
Written Test

b.



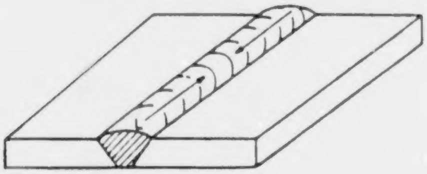
29. Identify results of longitudinal and transverse stress in basic welds. Circle the number of the item that best describes each of the following illustrations.

a.



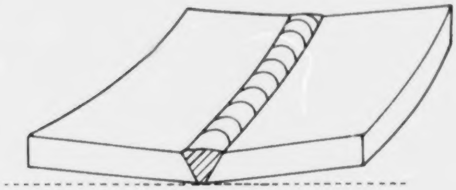
(1) Distortion down a butt weld to indicate transverse stress
(2) Distortion across a butt weld to indicate transverse stress

b.



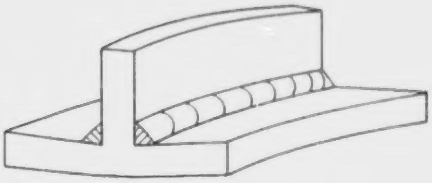
(1) Distortion across a butt weld to indicate transverse stress
(2) Distortion down a butt weld to indicate longitudinal stress

c.



(1) A butt weld with extreme longitudinal stress
(2) A butt weld showing the combination of longitudinal and transverse stress

d.



(1) A fillet weld showing extreme longitudinal stress
(2) A fillet weld showing the effect of longitudinal and transverse stresses in combination

30. Complete statements about heat applications and their uses in weld quality control. Circle the material that best completes each of the following statements.

    a. Preheating a part before a welding process starts can help control cracking, reduce stresses from shrinkage, and promote slower cooling to prevent excessive (**hardening**) (**distortion**).

    b. Heating between welding passes with interpass heat helps maintain the (**required temperature**) (**filler metal temperature**)

    c. Postheating after the welding process ends allows slow cooling which promotes stress relief (**in the weld**) (**in the weld and the base metal**).

31. Select true statements about guidelines for preheating in special conditions. Place an "X" beside each true statement.

    ______a. Preheat when welding large or bulky parts or when welding parts with complicated shapes.

    ______b. Preheat when atmospheric temperature is cold or when the temperature of the parts is cold.

    ______c. Preheat when the carbon or alloy content of steel is low.

    ______d. Preheat when a slow welding speed is specified.

    ______e. Preheat when small-diameter welding rods are specified.

Written Test

32. Complete statements about methods of preheating and postheating and their applications. Circle the material that best completes each of the following statements.

    a. Preheat and postheat (**odd-shaped**) (**small**) parts in a furnace.

    b. Preheat and postheat (**long**) (**bulky**) parts by using acetylene, propane, or oil torches in banks of two or more.

    c. Preheat and postheat (**bulky**) (**long or wide**) parts with electrical strip heaters clamped parallel to joints, about 6″ from the seam.

    d. For (**low-carbon steel**) (**general service**) preheating and postheating, use a natural gas torch with compressed air and a single-orifice heating tip.

    e. When preheating or postheating with a torch, use a heating tip (**the same size as**) (**one size larger than**) the tip required to oxyacetylene weld the joint.

    f. For torch heating (**steel rails**) (**large parts**), use a torch with a multiflame head or rosebuds.

33. Match torch preheating techniques with their applications. Place the number of the technique in the blank beside the appropriate application.

______a. Applying heat at one specific point so that cooling will cause a slight inward movement around the joint and help control nondirectional distortion

______b. Applying heat along a seam or perpendicular to a seam to control direction distortion

______c. Applying heat along a side to shorten it, or applying other heating techniques to a certain side of a plate in order to flatten it

1. Slot heating
2. Convex heating
3. Spot heating

Written Test

34. Match types of steels with their recommended preheat temperatures. Place the number of the steel in the blank beside the appropriate preheat temperature.

_______a. Preheating is not normally required, but if temperature is below 50°F, preheat to about 100°F or higher, if the plate thickness is over 1″.

_______b. Preheat from 200°F to 400°F, retain the same interpass temperature, and postheat is recommended, especially on thicker metals.

_______c. Preheat and interpass temperatures should be a minimum of 400°F, and postheat is recommended, especially on thicker metals.

1. Medium-carbon steels
2. Mild steels
3. High-carbon steels

35. Match temperature-sensing devices with their uses. Place the number of the device in the blank beside the appropriate use.

_______a. Portable thermometers used to measure surface heat

_______b. Temperature-sensing devices that may be attached to the work, but more often are used in heating ovens or postweld heat treatment processes

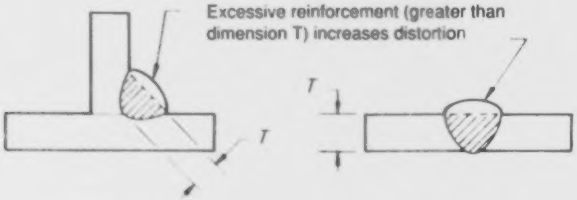
_______c. Temperature-sensing devices available in different degrees; can be used to indicate localized temperature; may be used in pairs to indicate a high and low temperature range

1. Crayons and pellets
2. Pyrometers
3. Thermocouples

Written Test

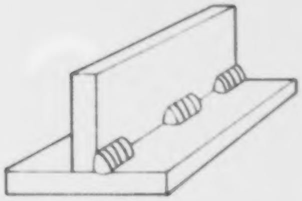
36. Identify methods for controlling distortion with the welding process. Circle the number of the information that best describes the type of distortion control in the following illustrations.

a.


Excessive reinforcement (greater than dimension T) increases distortion
T
T

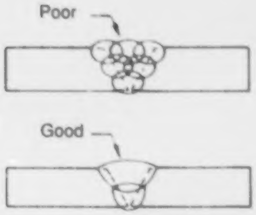
(1) Use as few passes as specifications permit.
(2) Do not overweld.
(3) Place welds along a neutral axis.

b.



(1) Use intermittent welds.
(2) Use backstep welding.
(3) Do not overweld.

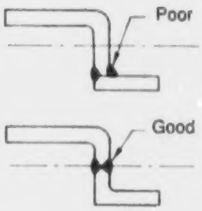
c.



(1) Use as few passes as specifications permit.
(2) Do not overweld.
(3) Use intermittent welds.

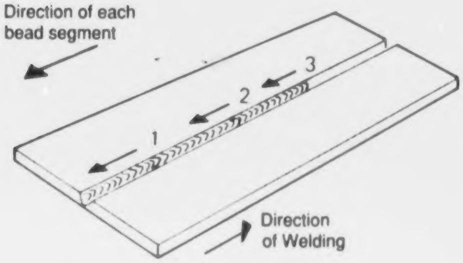
Written Test

d.



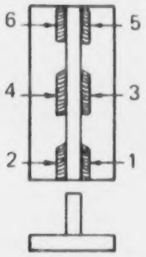
(1) Weld in an alternating sequence.
(2) Use backstep welding.
(3) Place welds at or along a neutral axis.

e.


Direction of each bead segment
3
2
1
Direction of Welding

(1) Use backstep welding.
(2) Use as few passes as specifications permit.
(3) Use intermittent welds.

f.



(1) Weld in an alternating sequence.
(2) Use backstep welding.
(3) Use intermittent welds.

Written Test

37. Select true statements about guidelines for controlling distortion with mechanical means. Place an "X" beside each true statement.

_____a. Modify the edge preparation, especially on thicker metals; decrease the bevel angle and increase the root opening, or use a J- or U-joint design.

_____b. Use a single V-joint in place of a double V-joint because the single joint requires about half the weld metal for the same plate thickness.

_____c. Anticipate the places and amount of shrinkage and preset parts so that shrinkage forces will pull them into alignment during welding.

_____d. Prebend and clamp parts to make the joint longer so that shrinkage will cause the joint to lie flat as the plate cools and the clamps are removed.

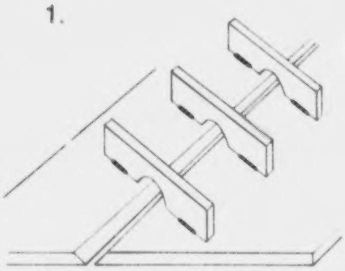
_____e. Clamp parts front to back, if possible, to help distortion forces work against each other for shrinkage control.

38. Match methods for controlling distortion with restraining devices with their application. Place the number of the illustration in the blank beside the appropriate application.

_____a. When welding butt plates, tack weld clips along the edges of one plate, then drive wedges under the open side of the clips to force the edges into alignment.

_____b. For aligning plates, tack weld a yoke to a backup strip, slip the yoke between the edges, then place a yoke guide on top of the plates and drive a wedge through the first yoke to complete alignment.

1.

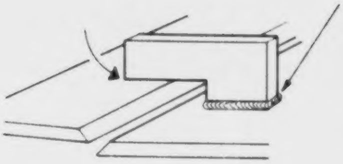


Written Test

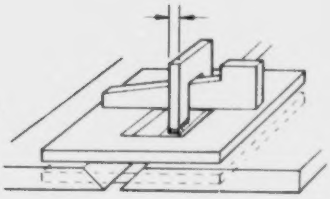
______c. For butt welds on thicker plates, tack weld a yoke on top of one plate, tack weld a bar to the top of the second plate, then drive a wedge between the yoke and the bar to complete alignment.

______d. Several strongbacks together could restrain a weld so much that the weld could crack as it cools, so when several strongbacks are required, position them at a 45° angle across the joint to allow for transverse movement.

2.



3.



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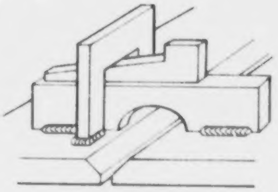


Basic Metals and Metallurgy
Unit 4

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Identify Selected Metals by Appearance, Color, and Corrosion Characteristics Rating ______

Comments: ______________________

____

Job Sheet 1—Conduct Magnet Tests to Identify Common Metals Used for Welding Rating ______

Comments: ______________________

____

Job Sheet 2—Conduct Chisel Tests to Identify Common Metals Used for Welding Rating ______

Comments: ______________________

____

Job Sheet 3—Conduct Spark Tests to Identify Common Metals Used for Welding Rating ______

Comments: ______________________

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ______________________

____

Teacher Signature ______________________ Date ________

Student Signature ______________________ Date ________

***Permission to duplicate this form is granted.**

Basic Metals and Metallurgy
Unit 4

Teacher Supplement 1—Heating Ranges of Ferrous Metals

The heating ranges for steels with different carbon content reveal significant information about the reaction of no-carbon steels to heat. Use the following information along with Transparency 2 to introduce students to heat ranges. Relate heat changes to specific changes in characteristics of steel at varying temperatures so students will gain the basics of a metallurgical approach to metals.

Start at the bottom of the transparency with the sub-zero temperature range. Point out to students the extent of the range, from 0°F to minus 300°F. The significant changes in almost all metals in the sub-zero range is that they show a decrease in impact resistance. In fact, the lower the temperature, the lower the impact resistance.

Now as you move up the heat range chart to the color-coded heat ranges—black heat range, red heat range, white heat range—note that the color-coded ranges are based on steel with zero percent carbon. The rule of thumb for using the chart for other steels is: as carbon content in steel increases, preheating temperatures increase and temperatures above the transformation range decrease. With that rule of thumb in mind, you should be able to use steel samples from your own shop to demonstrate temperature ranges.

Start with the black heat range which extends from 0°F to 1000°F. The black heat range includes the preheating range for welding, a range which runs from about 60°F to just above 700°F. Note that the black heat range includes the blue brittle range from 300°F to 700°F. The blue brittle is the range where peening or working of steels should not be attempted. Metals are more brittle at the blue brittle range than they are above or below the blue brittle range. Note too that the black heat range includes the nitriding range from about 950°F to 1000°F. In manufacturing, certain steels are subjected to ammonia gas for long periods to give them extremely hard surfaces as the metals absorb nitrogen.

The red heat range extends from 1000°F to 2050°F. The red heat range includes the stress relieving range which runs from about 1120°F to 1250°F. Stress relief means the metal is held at the stress relieving range long enough to relieve locked-up stresses. Then, the metal is cooled slowly to produce what is called "process annealing."

The spheroidizing range is also in the red heat range. When a metal is held long enough at a temperature between 1250°F and 1350°F, it becomes soft enough to provide good machinability. This is accomplished in the spheroidizing range.

The range from 1350°F to 1690°F is called the transformation range. In the transformation range, steels undergo radical changes which affect their properties.

Austenite steel is produced in the annealing and normalizing range that extends from 1400°F to 1750°F. When steels are held at this temperature long enough, then slowly cooled, it produces a steel that has small grain size, softness, and good ductility.

Teacher Supplement 1

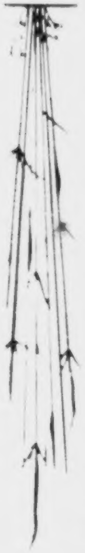
The carburizing range extends from about 1600°F to 1810°F. In this range, carbon can be dissolved into the surface of steel to create hard, high-carbon steel.

The forging range extends from 1810°F to 2400°F. Temperatures in the forging range permit metals to be mechanically worked or fused together.

Heating ranges play a significant role in metal manufacturing. A knowledge of heating ranges is a valuable asset for welders because heat and its proper application can help control distortion and produce a quality product.

Spark Test Characteristics

Low-Carbon Steel



Color-white

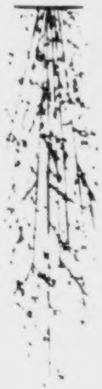
Average length of stream with power grinder - 70 in.

Volume -moderately large

Shafts shorter than wrought iron and in forks and appendages

Forks become more numerous and sprigs appear as carbon content increases

High-Carbon Steel



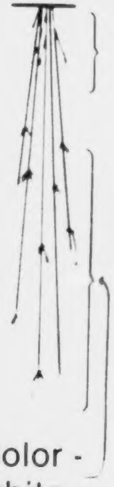
Color -white

Average stream length with power grinder - 55 in.

Volume -large

Numerous small and repeating sprigs

Stainless and Other Alloy Steel



Color -straw yellow

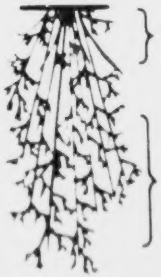
Stream length varies with type and amount of alloy content

Shafts may end in forks, buds or arrows, frequently with break between shaft and arrow. Few, if any, sprigs

Color - white

Spark Test Characteristics
(Continued)

White Cast Iron



Color - red

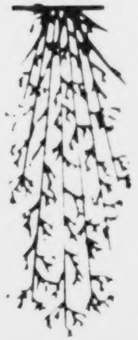
Color -straw yellow

Average stream length with power grinder - 20 in.

Volume -very small

Sprigs -finer than gray iron, small and repeating

Gray Cast Iron



Color - red

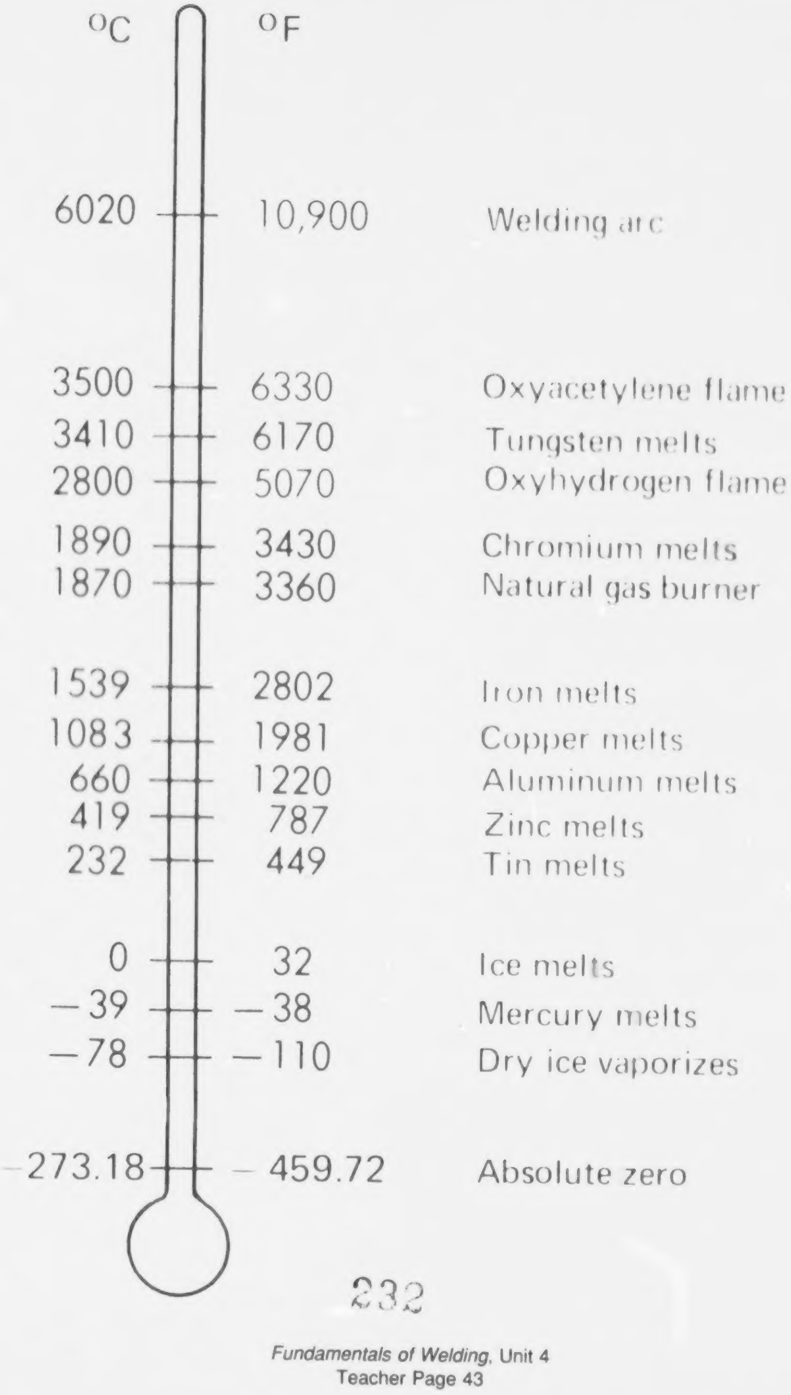
Color -straw yellow

Average stream length with power grinder - 25 in.

Volume -small

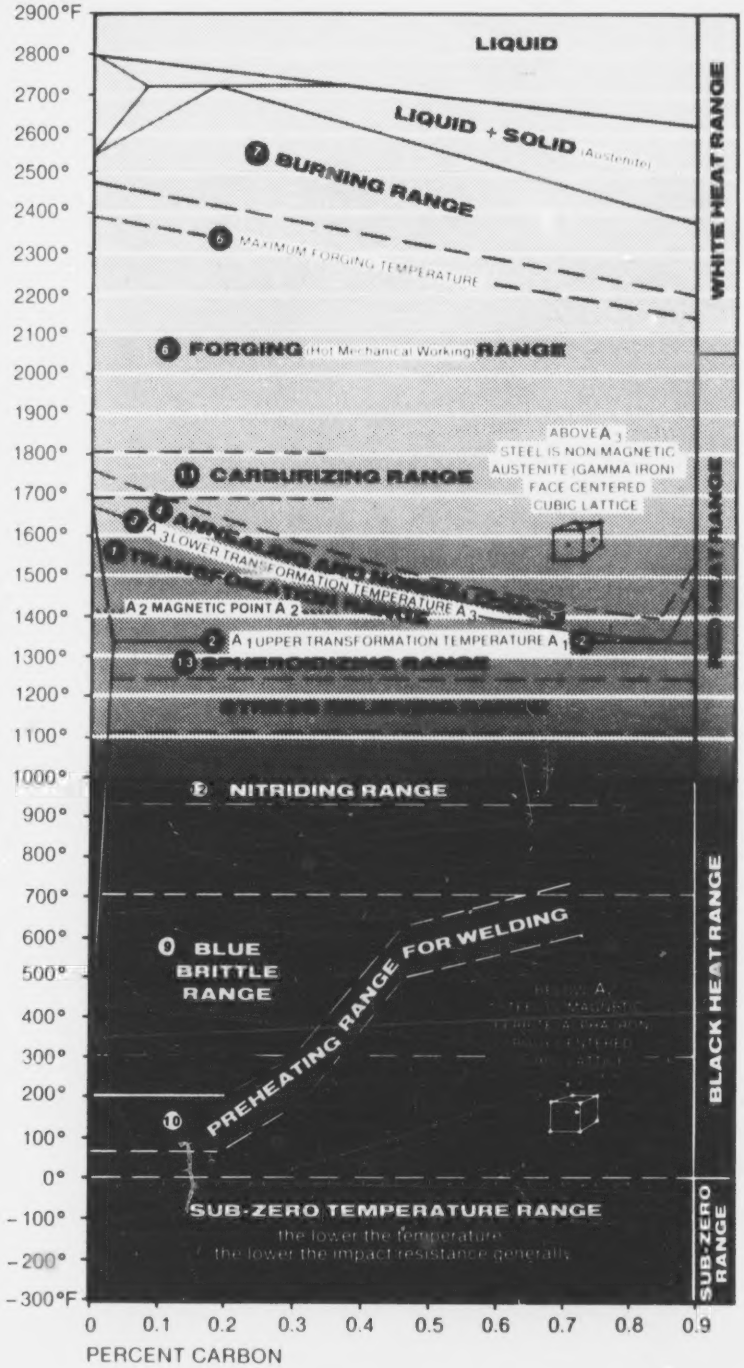
Many sprigs, small and repeating

Metal Melting Points and Other Temperatures



°C	°F	
6020	10,900	Welding arc
3500	6330	Oxyacetylene flame
3410	6170	Tungsten melts
2800	5070	Oxyhydrogen flame
1890	3430	Chromium melts
1870	3360	Natural gas burner
1539	2802	Iron melts
1083	1981	Copper melts
660	1220	Aluminum melts
419	787	Zinc melts
232	449	Tin melts
0	32	Ice melts
−39	−38	Mercury melts
−78	−110	Dry ice vaporizes
−273.18	−459.72	Absolute zero

Heating Ranges for Ferrous Metals



Aluminum Hardness and Tempering Designations

T#	Process	Applications
T1	Naturally aged to a substantially stable condition	Castings which have their strength increased by room-temperature aging from the as-cast condition
T2	Annealed cast products only	Casting which have their ductility improved and dimensional stability increased with an annealing treatment
T3	Solution heat-treated and then cold worked	Products cold worked to improve strength or to achieve the effect of cold work in flattening or straightening
T4	Solution heat-treated and naturally aged to a substantially stable condition	Products which are not cold worked after solution heat-treatment
T5	Artificially aged from the as-cast condition	Products which are aged at elevated temperatures from the as-cast condition to improve mechanical properties or dimensional stability or both
T6	Solution heat-treated and then artificially aged	Products which are not cold worked after solution heat-treatment
T7	Solution heat-treated and then stabilized	Products which are stabilized to carry them beyond the point of maximum strength to provide control of special characteristics
T8	Solution heat-treated, cold worked, then artificially aged	Products which are cold worked to improve strength for certain applications
T9	Solution heat-treated, artificially aged, and then cold worked	Products which are cold worked to improve strength for certain applications
T10	Artificially aged and then cold worked	Products which are artificially aged after an elevated-temperature, rapid-cool process, and then cold worked to improve strength

Basic Metals and Metallurgy
Unit 4

Information Sheet

1. **Terms and definitions**

   a. **AA** — Aluminum Association

   b. **AISI** — American Iron and Steel Institute

   c. **Compatibility** — Two or more metals that have similar properties that can readily be joined

   d. **Extruding** — The process of forcing a metal through a special die to give it shape and length

   e. **Filler metals** — Metals added in making a brazed, welded, or soldered Joint

   f. **Interpass temperature** — Maintenance of heat to a base metal and weld passes during a welding process

   g. **Metallurgy** — The science that explains the properties, behavior, and internal structure of metals

   h. **Postheating** — Application of heat to a weld and/or a base metal after a welding operation to promote a slower cooling rate and relieve stresses in the base metal and the weldment

   i. **Preheating** — Application of heat to a base metal before welding or cutting

   j. **SAE** — Society of Automotive Engineers

   k. **Strain-hardened** — A metal that has had its strength, hardness, and brittleness increased with or without heating

   l. **Weldment** — Assembly of two or more metal parts with welding

2. **Advantages of proper metal identification**

   a. Proper metal identification helps determine the welding processes that are most effective and economical with a particular metal.

   b. Proper metal identification helps establish requirements for preheating, interpass heating, and postheating.

   c. Proper metal identification helps establish what metals are compatible so that proper filler metals can be selected.

Information Sheet

3. Basic metals, alloys, and properties and their definitions

a. **Ferrous metals** — Metals that contain iron as the major element

Example: Low, mild, medium, and high-carbon steels, and cast iron

b. **Nonferrous metals** — Metals that contain no iron or an extremely small amount of iron

Example: Aluminum, copper, zinc, lead, tin, nickel, silver, titanium, and gold

c. **Alloy** — A single element dissolved together with a metal or metals in a solid solution

d. **Alloy steels** — Steels formed by adding one or more additional elements to give the steels special properties

Note: Alloys may be either ferrous or nonferrous, but alloy steels are always ferrous.

e. **Mechanical properties** — The measure of how materials behave under applied loads

f. **Physical properties** — Properties such as melting point or thermal conductivity which are affected when metals are subjected to heat

g. **Chemical properties** — Properties which involve corrosion, oxidation, and reduction

4. Metal identification tests and their characteristics

a. Appearance—Surface color reveals the presence of oxidation; when exposed to weather, some metals will rust, others tarnish, and others remain oxidation free.

b. Chemical—Certain chemicals or acids applied to metals cause different reactions in different metals.

Example: When applied to stainless steel, a weak solution of nitric acid or copper sulfate remains clear, but when applied to carbon steel, it darkens.

c. Chisel—When chipped with a chisel, certain metals produce a continuous chip, others break up into small particles, and others cannot be chipped.

Example: Low-carbon steel chips easily and leaves a continuous chip, but cast iron is difficult to chip and breaks up into small pieces.

Information Sheet

d. File—Nonferrous metals are usually easy to file, but ferrous metals are difficult to file.

e. Magnet—A magnet sticks to ferrous metals, but it will not stick to nonferrous metals.

f. Sound—When struck with a hammer, most metals have a characteristic ring or lack of it.

Example: Steel has a higher-pitched ring than cast iron

g. Spark—Ferrous metals have definite spark patterns, but nonferrous metals have no spark pattern.

5. **Mechanical properties of metals and their characteristics**

a. **Brittleness** — The tendency of certain metals to break or fracture if bent or struck sharply

b. **Ductility** — The capacity of a metal to be permanently stretched without breaking

c. **Elasticity** — The capacity of a metal to return to its original size and shape when the force that changed it is removed

d. **Elastic limit** — The incapacity of a metal to return to its original size and shape when the force that changed it is removed

e. **Elongation** — The measure of ductility of material measured in a tension test

f. **Fatigue** — The tendency of some metals to break or fracture under a repeated or sustained load

g. **Hardness** — The capacity of metal to resist penetration, abrasion, and deformation

h. **Impact resistance** — The capacity of a metal to absorb without failure the impact of a load applied rapidly

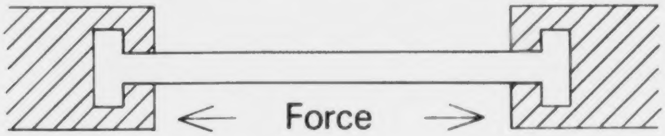
i. **Malleability** — The capacity of a metal to be hammered or rolled into shape without breaking

j. **Strength** — The capacity of a metal to resist changing its shape or size when exposed to external forces

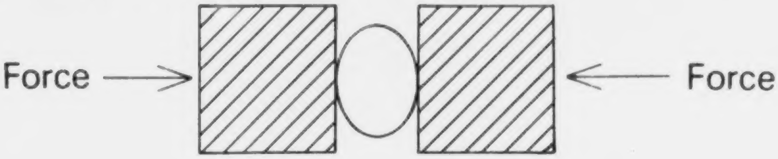
Information Sheet

6. Types of mechanical strengths and their characteristics

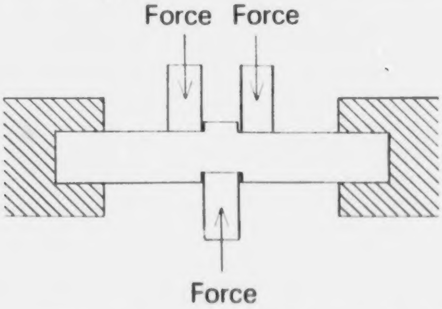
a. Tensile strength — The capacity of a metal to resist being pulled apart



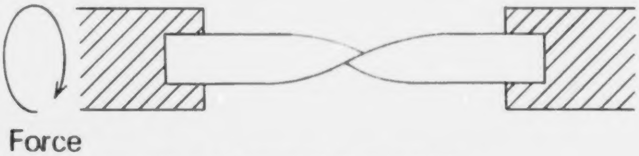
b. Compressive strength — The capacity of a metal to resist being pushed or crushed together



c. Shear strength — The capacity of a metal to withstand a sustained load across its cross section



d. Torsional strength — The capacity of a metal to resist twisting forces



7. Physical properties of metals and their characteristics

a. Density is the weight of a given piece of metal in relation to a unit size.

Example: A cubic foot of aluminum weighs less than a cubic foot of steel, so steel has a greater density than aluminum.

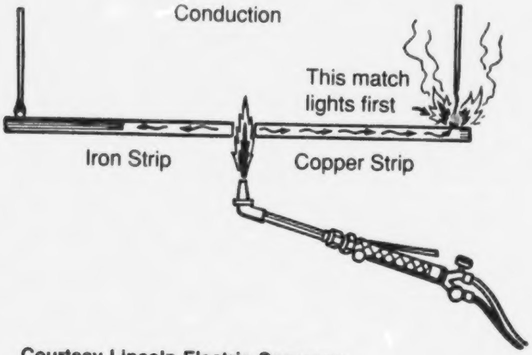
b. Electrical conductivity is the capacity of a metal to conduct electrical current.

Example: Copper has a much high electrical conductivity than steel and is used in many electrical wires.

Information Sheet

c. Thermal conductivity is the capacity of a metal to conduct heat.

Example: Silver and copper are metals that have high thermal conductivity.



Courtesy Lincoln Electric Company

d. Thermal expansion is the tendency of metals to expand when heated, as expressed in terms of coefficient of expansion.

Note: Thermal expansion is extremely important in welding because a metal such as aluminum which has a high coefficient of thermal conductivity will readily spread heat throughout the workpiece and minimize distortion at the weld zone, but metals such as stainless steel with a low coefficient of thermal conductivity will localize the heat in the weld zone and cause a greater amount of distortion.

e. Melting point is the point to which a metal must be heated before it will melt.

8. Steel identification systems and their characteristics

a. The SAE (Society of Automotive Engineers) and AISI (American Iron and Steel Institute) steel with a number system for the principal alloying ingredients in the steel.

(1) 1 indicates carbon.

(2) 2 indicates nickel.

(3) 3 indicates nickel-chromium.

(4) 4 indicates molybdenum.

(5) 5 indicates chromium.

(6) 6 indicates chromium-vanadium.

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(7) 7 indicates tungsten.

(8) 8 indicate nickel-chromium-molybdenum.

(9) 9 indicates silicon-manganese.

b. The AISI (American Iron and Steel Institute) also identifies steel with a letter system to designate how the steel was produced.

(1) A references open-hearth alloy steel.

(2) B references acid Bessemer carbon steel.

(3) C references basic open-hearth carbon steel.

(4) D references acid open-hearth steel.

(5) E references steel processed in an electric furnace.

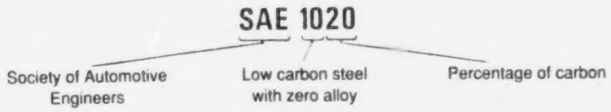
c. SAE and AISI identification systems both give place values to four-digit number codes.

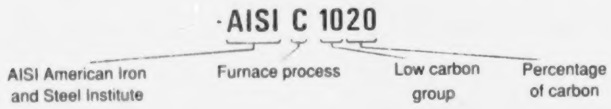
(1) The first digit indicates the type of alloy.

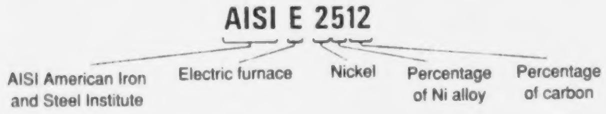
(2) The second digit indicates the percentage of the alloy designated in the first digit.

(3) The last two digits indicate the percentage of carbon in the steel.

Examples:


SAE 1020
Society of Automotive Engineers
Low carbon steel with zero alloy
Percentage of carbon


AISI C 1020
AISI American Iron and Steel Institute
Furnace process
Low carbon group
Percentage of carbon


AISI E 2512
AISI American Iron and Steel Institute
Electric furnace
Nickel
Percentage of Ni alloy
Percentage of carbon

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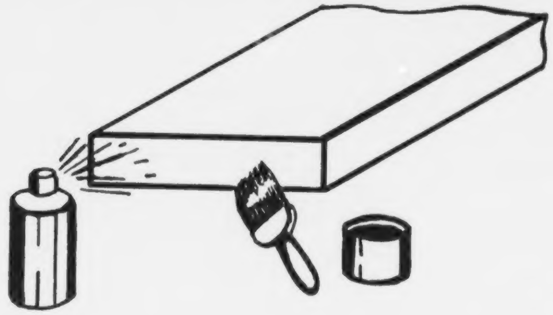
d. Color coding is a system that uses colors painted on the ends of steel bars or sheets to indicate the type of steel.

Note: Color coding varies with each manufacturer, so identification requires a guide from the mill that produced the steel; when working with color coded stock, start from the opposite end of the coloring so the stock can still be quickly identified even after part of it has been used.



e. UNS (Unified Numbering System) is a system that uses a five-digit number with a letter prefix that designates a general ferrous metal or alloy group.

Unified Numbering System
Ferrous Metals

ID Letter and Number	General Metal or Alloy Group
000001-D99999	General Metal or Alloy Group
F00001-F99999	Cast iron, carbon, and low-alloy steel castings
G00001-G99999	Carbon and alloy steels (AISI and SAE)
H00001-H99999	H steels (AISI)
K00001-K99999	Other steels and ferrous alloys
S00001-S99999	Stainless steels
T00001-T99999	Tool steels

9. Carbon steel classifications, characteristics, and typical uses

Classification	Characteristics	Typical Uses
Low carbon	0.07% to 0.15% carbon	Nails, iron bars and rods, auto bodies, and pipes
Mild steel	0.15% to 0.30% carbon	Gears, shafts, bolts, metal frames, angles, and channels
Medium carbon	0.30% to 0.50% carbon	Axles, shafts, machine bolts, boilers, hammers, and sledges
High carbon	0.50% to 1.00% carbon	Screwdrivers, crow bars, axes, springs, razor blades, and fine cutters

10. Principal steel alloys and their uses

a. Carbon — Used to make steels hard and strong

Note: The largest tonnage of all steel produced is low, medium, or high-crbon steel, with low carbon steel the most produced of the three.

b. Cobalt — Used to make steels that will remain hard when subjected to very high temperatures

c. Nickel — Used to make special steels with improved ductility while maintaining strength and toughness and a high resistance to corrosion and shock

d. Silicon — Used to make special steels that are hard and brittle

e. Molybdenum — Produces the greatest hardening effect of any element except carbon

f. Chromium — Increases tensile strength and hardness, as well as resistance to corrosion and oxidation

Information Sheet

11. Alloy steel classifications, characteristics, and typical uses

Classification	Characteristics	Typical Uses
Nickel steel	Strong and hard, resists corrosion, withstands shocks, vibration, and wear	Wire cables, railroad and car axles, and steel rails
Chromium steel	Fine grain, tough and strong, resists corrosion, shocks, and scratches	Auto bearings and safes
High chromium steel (Stainless steel)	Does not corrode, has a bright, silvery finish that looks good	Sinks, tables, and food service items subject to high standards of cleanliness
Chrome-nickel steel	Hard and strong	Auto gears, springs, axles, and armor plate
Manganese steel	Tough and strong, can resist strain, shock, and hammering	Jaws of rock crushers, chains, gears, and safes
Molybdenum steel	Tough and strong, resists heat and impact wear	Auto parts, high-grade machinery, and roller bearings
Tungsten steel	Hard, fine grained, and resists heat	High-speed metal cutting tools
Tungsten steel (Magnet steel)	Holds magnetism well	Electrical measuring instruments
Tungsten steel (Tungsten carbide)	Hardest man-made metal	Cutting tools and dies
Vanadium steel	Tough, but lightweight, fine grained, and resists shock	Auto axles, gears, and springs
Stellite steel	Extremely hard	Heavy cutting tools
High-speed steel	Self-hardening steel	Cutting tools, taps, and drills

Information Sheet

12. Iron classifications, characteristics, and typical uses

Classification	Characteristics	Typical Uses
Wrought iron	Resists corrosion, withstands shock, is malleable and easy to bend hot or cold	Rivets, bolts, nails, horseshoes, and ornamental iron
Gray cast iron	Relatively inexpensive, high compressive strength, but low tensile strength and brittle	Large pipes, stoves, water hydrants, and machinery frames
White cast iron	Very hard and brittle	Machine parts subjected to extreme wear or abrasion
Malleable cast iron	Tougher and more impact resistant than other cast irons	Farm tools, implement parts, and railroad equipment

13. Guidelines for identifying metals by color and characteristics

a. For low, medium, and high-carbon steels, look for new stock to be dark gray; these grades of steel rust with age, and rust rapidly when stored outside.

b. For manganese steels, look for a dull metallic surface on new stock: these steels rust with age, and rust rapidly when stored outside.

c. For stainless steels, look for bright, silvery-smooth surfaces; some grades of stainless rust with age and other grades tarnish.

d. For cast iron, look for a dull, gray color with evidence of the sand mold on new stock; cast irons rust rapidly in almost any environment.

e. For wrought iron, look for new stock to be light gray and smooth; wrought irons rust rapidly in almost any environment.

f. For aluminum, look for new stock to have a silvery-white, smooth surface; this light-weight metal has high corrosion resistance.

g. For copper, look for a reddish-brown, dull finish on new stock; copper resists corrosion, but it will tarnish.

h. For nickel, look for a hard, white finish; nickel resists rust and corrosion.

Information Sheet

14. Aluminum, its characteristics and uses

a. Aluminum is most used and most abundant of the nonferrous metals.

b. Aluminum is a silvery-white metal with a brilliant surface beauty that resists corrosion and is maintenance free.

c. Pure aluminum is very soft and difficult to use, so it is usually combined with an alloy to change its characteristics.

d. Aluminum is a good conductor of electricity, an excellent thermal reflector when it is polished, and a good thermal conductor in other forms.

e. Aluminum is both malleable and ductile and can easily be formed into shapes or into wire.

f. Aluminum is available in sheets, plates, bars, wires, pipes, tubes, and a great number of extruded forms.

15. Basics of the *commercial* system for identifying aluminum

a. The commercial system identifies aluminum by groups:

(1) The 1XXX group indicates aluminum of 99% or higher purity.

(2) The 2XXX group indicates aluminum with copper as the principal alloying element.

(3) The 3XXX group indicates aluminum with manganese as the principal alloying element.

(4) The 4XXX group indicates aluminum with silicon as the principal alloying element.

(5) The 5XXX group indicates aluminum with magnesium as the principal alloying element.

(6) The 6XXX group indicates aluminum with silicon and magnesium in approximate proportions as the principal alloying element.

(7) The 7XXX group indicates aluminum with zinc as the principal alloying element.

Note: There are other aluminum identification systems, but the *commercial* system was developed by the Aluminum Association to reflect common product references used by consumers and producers.

b. In the commercial identification system. there is a four-digit ID system especially for group 1XXX, and another four-digit ID system for the 2XXX plus group.

Information Sheet

16. Elements of the 1XXX group identification system

a. In the 1XXX group four-digit code, the first digit indicates a minimum of 99% aluminum.

b. The second digit indicates the degree of special control of impurities, with 0 indicating no special control and 9 indicating the highest special control.

c. The last two digits indicate the percent of aluminum beyond 99%.

Example: In the code 1030, the first digit indicates aluminum of 99% minimum, the second digit indicates no special controls for impurities, and the last two digits indicate .30% aluminum beyond 99% or 99.30% aluminum. In the codes 1130, 1230, and 1330, the second digits show there has been a degree of control for impurities.

17. Elements of 2XXX plus group commercial identification system

a. In the 2XXX plus group four-digit code, the first digit indicates the major alloying element in the aluminum.

b. The second digit indicates the amount of modification to the alloy, with 0 indicating no modification and 9 indicating the highest modification.

c. The last two digits have no special significance, but serve only to identify the different alloys in the groups as they pertain to manufacturing.

Example: In the code 2017, the first digit indicates a copper alloy and the second digit indicates no modification to the alloy. The last two digits have significance only to the manufacturer. However, the second digit in the code 2317 indicates a modification was made to the copper alloy.

18. Other elements of commercial aluminum identification and their meanings

a. Commercial aluminum identification uses both letters and numbers to indicate temper designations, the method and degree of tempering during the manufacturing process.

b. The basic designations are:

   (1) F means as fabricated with no special tempering.

   (2) O means annealed to produce a soft temper.

   (3) H means strain hardened to produce a stronger temper.

Information Sheet

c. The H designation reflects the hardness of the temper on a scale of 1 through 9, working on a base 8 system.

Example: With the base 8, the number 2 indicate 2/8 or 1/4 hard, 4 indicates 4/8 or 1/2 hard, 6 indicates 6/8 or 3/4 hard, 8 indicates full hard, and 9 indicates extra hard.

d. In addition to the H designations for strain hardening, T designations are used to indicate product that has been thermally treated with or without strain hardening to produce stable tempers.

Note: There are 10 basic T designations ranging from 1 to indicate room temperature aging to 10 to indicate artificial aging and cold working. See Transparency 5 for details of the T designations.

19. Aluminum quality designations and their meanings

a. AQ—Aircraft quality

b. CQ—Commercial quality

c. HTQ—High-tensile quality

20. Steps in using the commercial system to identify aluminum

a. Determine the number code series.

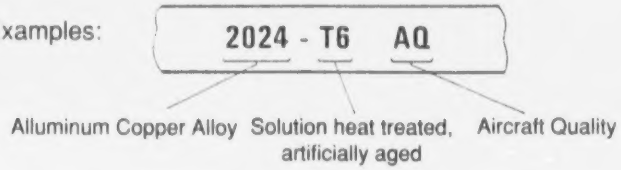
b. Determine the principal alloying element.

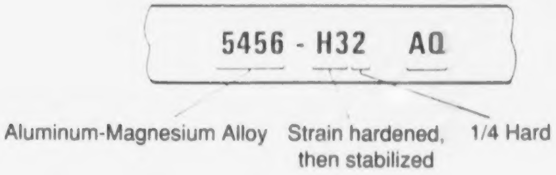
c. Determine the H or T designation.

d. Determine the degree of hardness.

e. Determine the quality designation.

Examples:


2024 - T6 AQ
Alluminum Copper Alloy
Solution heat treated, artificially aged
Aircraft Quality


5456 - H32 AQ
Aluminum-Magnesium Alloy
Strain hardened, then stabilized
1/4 Hard

Information Sheet

21. Other nonferrous metals and their typical uses

a. Beryllium—Used in the space program because of its light weight and high heat resistance

b. Copper—Used in electric and telephone wires and in industrial applications because it is the second best conductor of electricity; also alloyed with zinc or tin to make brass or bronze

c. Gold—Used for jewelry, coins, and coating electrical devices; usually alloyed with copper or nickel because it is too soft for general use

d. Lead—Used in auto batteries and alloyed with tin to make solder

e. Magnesium—Used in everything from lawnmower engine blocks to space vehicles because it is lightweight

f. Nickel—Used primarily as an alloy to toughen steel

g. Tin—Used for coating tin cans, and used as an alloy to make bronze, babbitt, pewter, and solder

h. Titanium—Used in supersonic aircraft because of its high heat resistance and capacity to withstand vibration; used in petrochemical applications because of its high corrosion resistance

i. Silver—Used in coins, jewelry, tableware, and in industrial applications because it is the best conductor of electricity

j. Zinc—Used to galvanize iron and steel for protection from rust

22. Guidelines for testing properties of metals

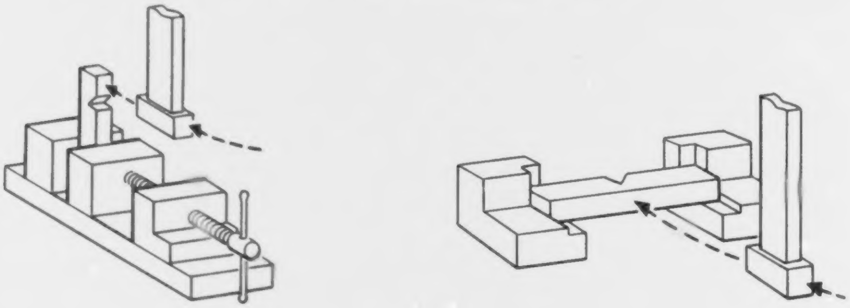
a. To test for hardness, use a Brinnel hardness tester or a Rockwell tester.

Note: The Brinell tester measures hardness by penetrating the metal with a hard sphere, and the Rockwell tester measures hardness by penetrating with a hard sphere or a sharp diamond point, depending on the hardness of metal.

b. To test for weld strength or ductility, use a hydraulic testing device that will have the power required to break or bend a welded sample.

Information Sheet

c. To test for impact resistance, use an Izod or a Charpy test with the specimen properly secured for accepting the test load impact.



Courtesy Lincoln Electric Company

d. To test for alloys by type and amount, use a spark test, and be sure the grinding wheel used in the test is free of residue.

23. Equipment requirements for spark testing

a. Spark testing requires a stationary or portable grinder with a medium-grit grinding wheel.

Note: 40 to 60 grit is the best range.

b. For spark testing with a stationary grinder, use an 8″ diameter grinding wheel with a turning rate of 3,600 rpm.

c. For spark testing with a protable grinder, use a 7″ disc with a turning rate of 5,000 rpm.

Note: Check the manufacturer's literature to determine rpm variance. Literature should indicate how rpm can be modified by changing the grinding wheel or disc diameter.

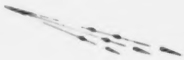
d. Use a clean grinding wheel for spark testing, and use a wire brush if the grinding wheel needs cleaning.

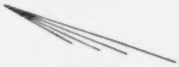
Note: Do not use a regular aluminum oxide grinding wheel when grinding aluminum because the grinding wheel will "load up" and be almost impossible to clean. When testing aluminum, use only a silicon carbide grinding wheel or disc.

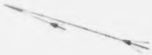
Information Sheet

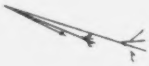
24. Guidelines for spark testing

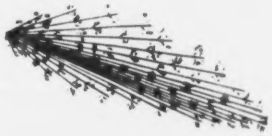
a. Learn to recognize the types of sparks produced by the metals you grind.

   (1) An arrow looks like this: 

   (2) A shaft looks like this: 

   (3) A fork looks like this: 

   (4) A spring looks like this: 

   (5) A stream looks like this: 

b. Look for specific colors as sparks fly from the grinding wheel.

   (1) A red color usually indicates cast iron.

   (2) A straw color at the end of a stream also indicates cast iron.

   (3) A white color usually indicates low- or high-carbon steel.

   (4) An orange color usually indicates chromium.

c. Evaluate the volume of sparks that fly from the grinding wheel.

   (1) Nonferrous metals produce a small volume.

   (2) Gray cast iron produces a small volume, and white cast iron produces a very small volume.

   (3) Low-carbon steel produces a moderately large volume.

   (4) High-carbon steel produces a large volume.

   (5) Stainless steel produces a moderate to large volume, depending on the type and amount of alloy in the steel.

Information Sheet

d. Note the distance the sparks fly from the grinding wheel.

   (1) Low-carbon steels throw shafts that terminate in forks about 70 inches long.

   Note: Shafts become shorter and more numerous as carbon content increases.

   (2) High-carbon steels throw numerous sprigs that look like sparklers about 55 inches long.

   (3) Stainless and other alloy steels throw shafts and arrows at varying distances, depending amount of alloy.

25. Characteristics of residual stresses

a. Residual stresses are the undesirable elements of distortion left in a part or an assembly after a welding operation is completed.

b. The forces and counterforces of residual stress can produce shrinkage, fractures, and other forms of distortion that make parts difficult or impossible to fit up.

c. Residual stresses can produce in base metals structural and metallurgical changes so severe that a welded assembly could fail in service and damage property or injure people.

26. Causes of residual stresses and distortion

a. In a welding process, filler metals and base metals expand uniformly in any direction if they are not restricted, but if they are restricted, they cannot expand uniformly.

b. After a welding process, filler metals and base metals contract as they cool, and will assume their original shape if unrestricted, but if restricted, they will not contract uniformly.

c. The lack of uniformity in expansion and contraction means that residual stresses will vary with joint design, welding procedure, and metal type and thickness.

d. Welding thick metals promotes residual stresses, and the thicker the metal, the more problems with residual stresses.

Information Sheet

27. Guidelines for changing the welding procedure to control stresses

a. Modify the joint design.

b. Minimize the heat input by modifying the welding process.

Example: Back step or intermittent welds

c. Select alternate filler metals or base metals.

d. Peen the weld lightly to help it stretch.

Note: Peen with care, because too much peening will add stresses or cause the weld to strain harden and become brittle.

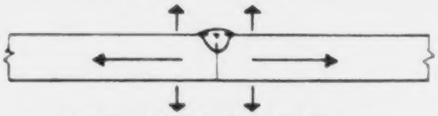
e. Stress relieve by using a postweld heat treatment.

f. Add thermal control by using preheating, interpass heating, postheating, or all three.

g. Add mechanical control by using clamps, wedges, or mechanical jigs and fixtures.

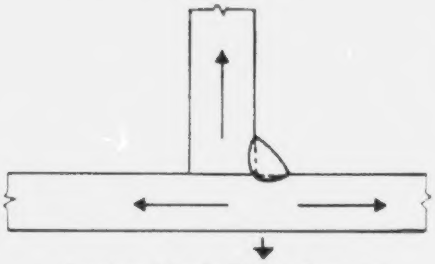
28. Routes for heat expansion in basic welds

a. In a normal butt weld, expansion occurs outward in all directions from the joint.



Courtesy Lincoln Electric Company

b. In a fillet weld, expansion also occurs outward in all directions.



Courtesy Lincoln Electric Company

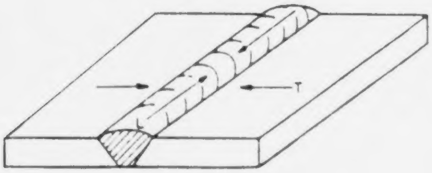
Note: Heat applied to a weld causes metal to expand, so how expansion occurs in basic welds provides valuable clues for controlling residual stresses.

Information Sheet

29. Results of longitudinal and transverse stress in basic welds

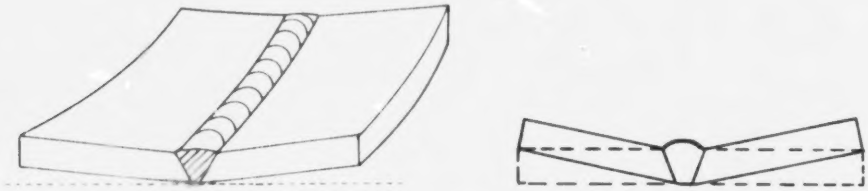
a. In a butt weld, the first passes can produce distortion **down** the length of the weld bead; this is called **longitudinal stress**.

b. In a butt weld, as the first passes solidify, the movement **across** the weld bead is restricted; this is called **transverse stress**.



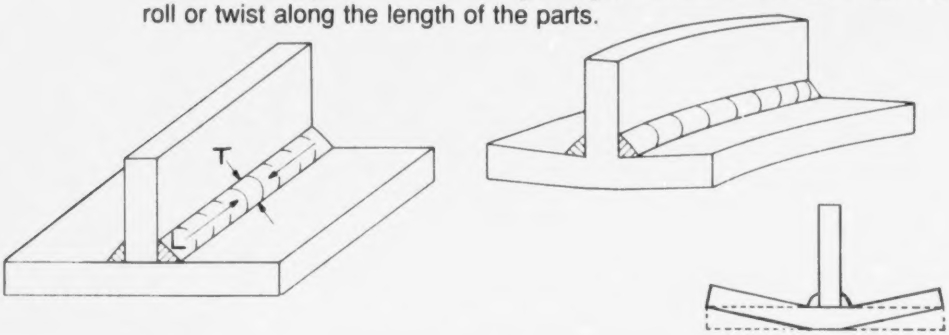
Courtesy Lincoln Electric Company

c. In a butt weld, the combination of longitudinal and transverse stresses results in distortion that usually causes the plates to rise from an even position to a slight angle.



Courtesy Lincoln Electric Company

d. In a fillet weld, the combination of longitudinal and transverse stresses not only causes a change from flat to a slight angle, but the combination can result in a roll or twist along the length of the parts.



Courtesy Lincoln Electric Company

Information Sheet

30. Heat applications and their uses in weld quality control

a. Preheating a part before a welding process starts can help control cracking, reduce stresses from shrinkage, and promote slower cooling to prevent excessive hardening.

b. Heating between welding passes with interpass heat helps maintain the required temperature.

Note: Most welding processes provide sufficient interpass heat, but on large assemblies, heating between passes may be required.

c. Postheating after the welding process ends allows slow cooling which promotes stress relief in the weld and the base metal.

31. Guidelines for preheating in special conditions

a. Preheat when welding large or bulky parts or when welding parts with complicated shapes.

b. Preheat when atmospheric temperature is cold or when the temperature of the part is cold.

c. Preheat when the carbon or alloy content of steel is high.

d. Preheat when a fast welding speed is specified.

e. Preheat when small-diameter welding rods are specified.

32. Methods of preheating and postheating and their applications

a. Preheat or postheat small parts in a furnace.

b. Preheat or postheat bulky parts by using acetylene, propane, or oil torches in banks of two or more.

c. Preheat or postheat long or wide parts with electrical strip heaters clamped parallel to joints, about 6″ from the seam.

d. For general service preheating or postheating, use a natural gas torch with compressed air and a single-orifice heating tip.

e. When preheating or postheating with a torch, use a heating tip the same size as the tip required to oxyacetylene weld the joint.

f. For torch heating large parts, use a torch with a multiflame head or rosebud.

Note: Torch heating is used frequently in shop work because it is handy, but it also provides a hot flame that burns clean to help avoid contaminating the weld zone.

Information Sheet

33. Torch preheating techniques and their applications

a. Spot heating—Applying heat at one specific point so that cooling will cause a slight inward movement around the joint and help control nondirectional distortion

b. Slot heating—Applying heat along a seam or perpendicular to a seam to control direction distortion

c. Convex—Applying heat along a side to shorten it, or applying other heating techniques to a certain side of a plate in order to flatten it

34. Types of steels and their recommended preheat temperatures

a. Mild steels—Preheating is not normally required, but if temperature is below 50°F, preheat to about 100°F or higher, if the plate thickness is over 1".

b. Medium-carbon steels—Preheat from 200°F to 400°F, retain the same interpass temperature, and postheat is recommended, especially on thicker metals.

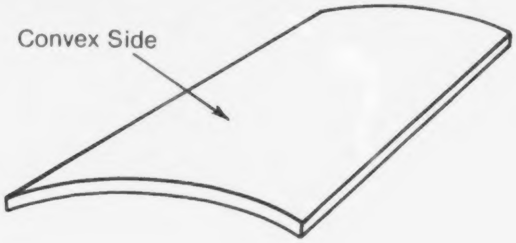
c. High-carbon steels—Preheat and interpass temperatures should be a minimum of 400°F, and postheat is recommended, especially on thicker metals.

35. Temperature-sensing devices and their uses

a. Pyrometers—Portable thermometers used to measure surface heat

b. Thermocouples—Temperature-sensing devices that may be attached to the work, but more often are used in heating ovens or postweld heat treatment processes

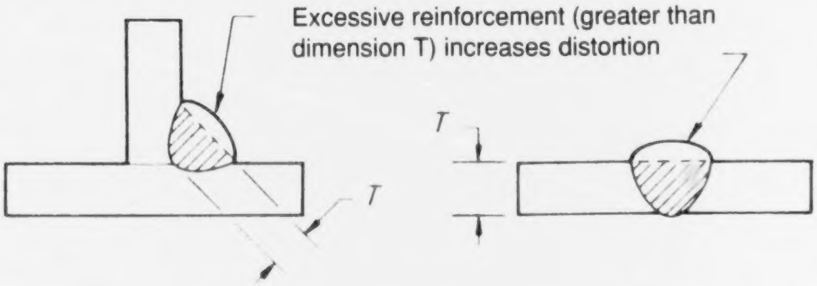
c. Crayons and pellets—Temperature-sensing devices available in different degrees; can be used to indicate a localized temperature; both crayons and pellets may be used in pairs to indicate a high and low temperature range



Information Sheet

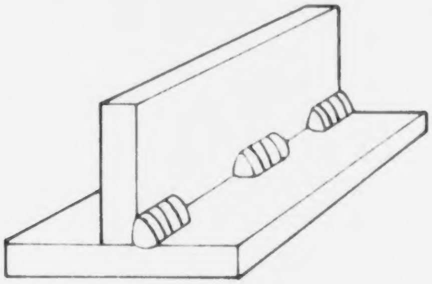
36. Methods for controlling distortion with the welding process

a. Do not overweld because excessive filler metal added to the joint increases shrinkage forces, but does not increase weld strength.


Excessive reinforcement (greater than dimension T) increases distortion
T
T

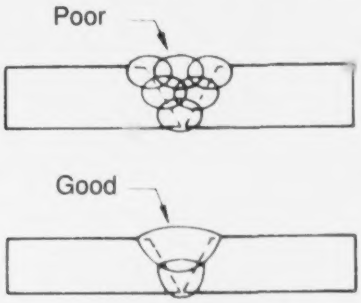
Courtesy Lincoln Electric Company

b. Use intermittent welds when you can because they provide strength, yet reduce the amount of heat and filler metal required.



Courtesy Lincoln Electric Company

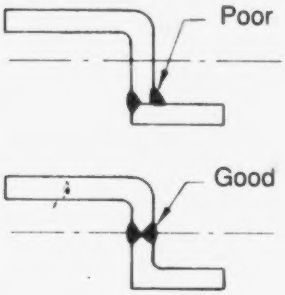
c. Use as few passes as specifications permit; larger electrodes and fewer passes are better than smaller electrodes and more passes.



Courtesy Lincoln Electric Company

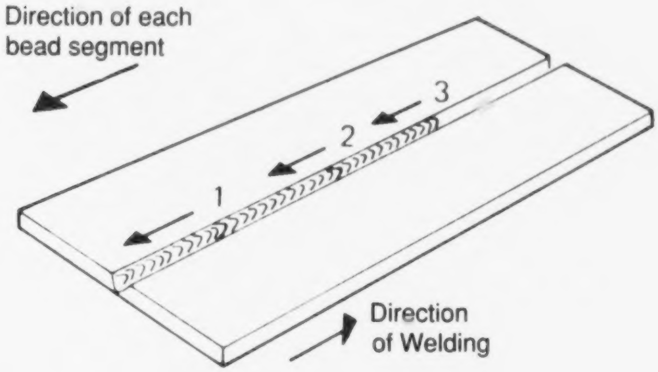
Information Sheet

d. Place welds at or along a neutral axis to lessen the leverage of forces that cause distortion.



Courtesy Lincoln Electric Company

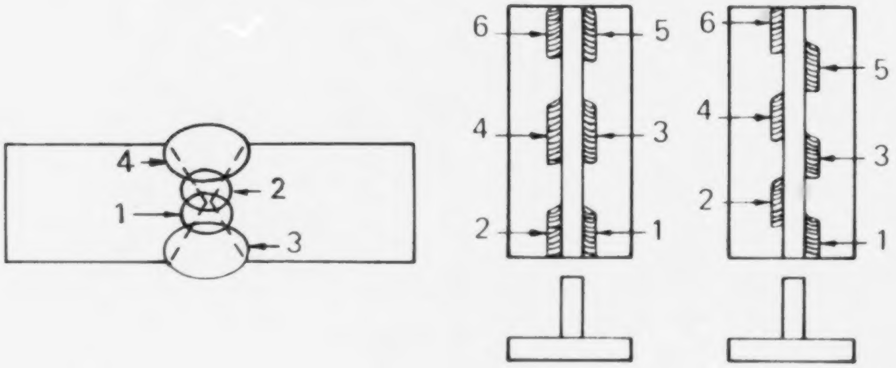
e. Use backstep welding; welding usually proceeds left to right, but place beads right to left in order to spread heat uniformly to the outer edges and to bring plates back into alignment.


Direction of each bead segment
1
2
3
Direction of Welding

Courtesy Lincoln Electric Company

Information Sheet

f. Weld in an alternating sequence; use intermittent welds alternately on fillet welds so that shrinkage in the second weld will counterbalance shrinkage in the first weld, and other alternate welds will counterbalance each other.

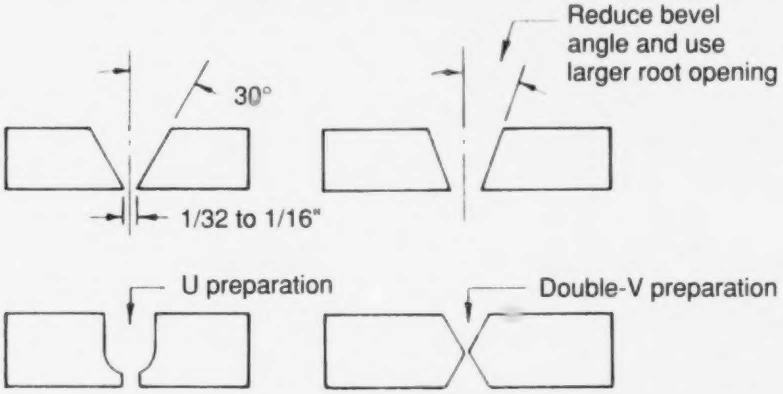

4
2
1
3
6
5
4
3
2
1
6
5
4
3
2
1

Courtesy Lincoln Electric Company

37. Guidelines for controlling distortion with mechanical means

a. Modify the edge preparation, especially on thicker metals; decrease the bevel angle and increase the root opening, or use a J- or U-joint design.

b. Use a double V-joint in place of a single V-joint because the double joint requires about half the weld metal for the same plate thickness.

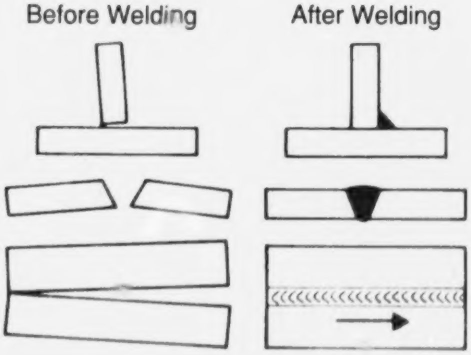

Reduce bevel angle and use larger root opening
30°
1/32 to 1/16"
U preparation
Double-V preparation

Courtesy Lincoln Electric Company

Information Sheet

c. Anticipate the places and amount of shrinkage and preset parts so that shrinkage forces will pull them into alignment during welding.

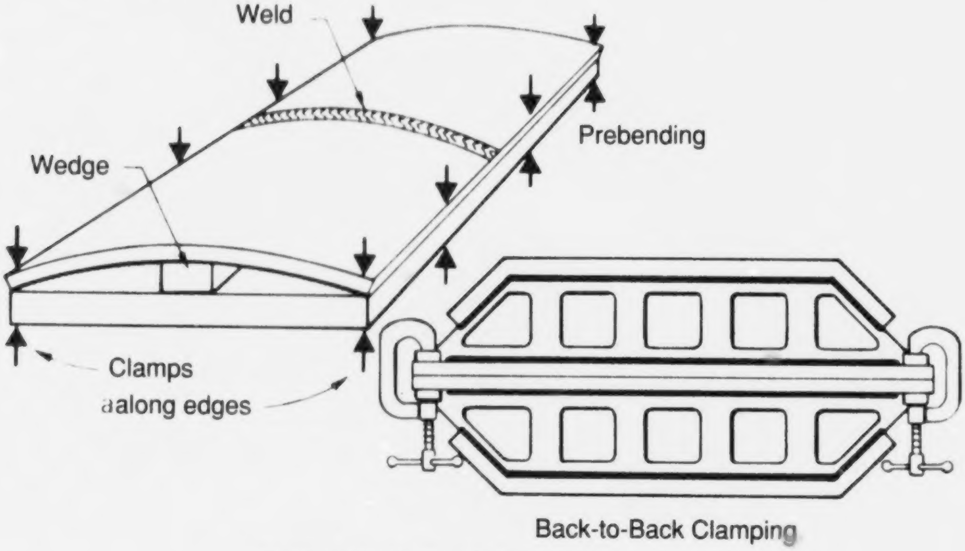
Note: Presetting parts requires good estimating, but a few practice welds should demonstrate how it works.


Before Welding
After Welding

Courtesy Lincoln Electric Company

d. Prebend and clamp parts to make the joint longer so that shrinkage will cause the joint to lie flat as the plate cools and the clamps are removed.

e. Clamp parts front to back, if possible, to help distortion forces work against each other for shrinkage control.

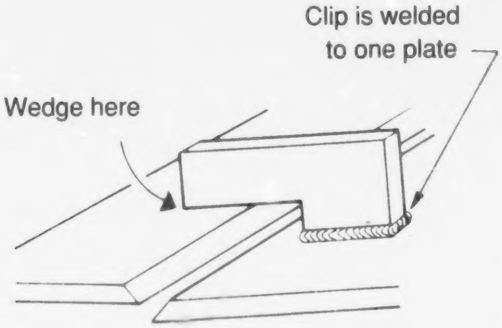

Weld
Wedge
Prebending
Clamps
along edges
Back-to-Back Clamping

Courtesy Lincoln Electric Company

Information Sheet

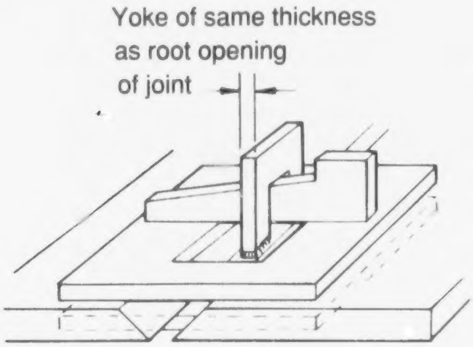
38. Methods for controlling distortion with restraining devices and their applications

a. When welding butt plates, tack weld clips along the edges of one plate, then drive wedges under the open side of the clips to force the edges into alignment.


Clip is welded to one plate
Wedge here

Courtesy Lincoln Electric Company

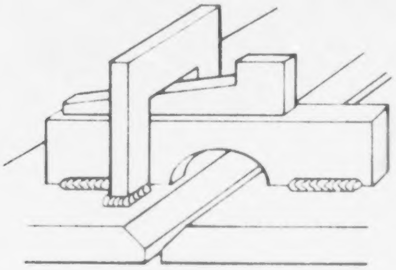
b. For aligning plates, tack weld a yoke to a backup strip, slip the yoke between the edges, then place a yoke guide on top of the plates and drive a wedge through the first yoke to complete alignment.


Yoke of same thickness as root opening of joint

Courtesy Lincoln Electric Company

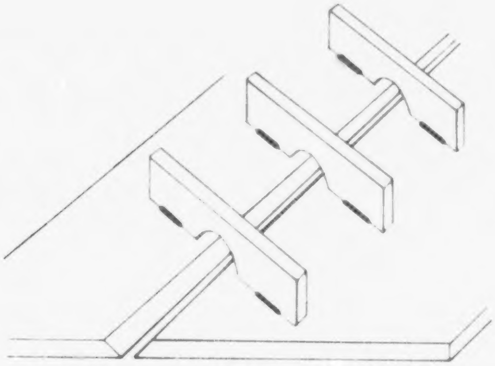
Information Sheet

c. For butt welds on thicker plates, tack weld a yoke on top of one plate, tack weld a bar to the top of the second plate, then drive a wedge between the yoke and the bar to complete alignment.



Courtesy Lincoln Electric Company

d. Several strongbacks together could restrain a weld so much that the weld could crack as it cools, so when several strongbacks are required, position them at a 45° angle across the joint to allow for transverse movement.



Courtesy Lincoln Electric Company

Basic Metals and Metallurgy
Unit 4

Assignment Sheet 1—Identify Selected Metals by Appearance, Color, and Corrosion Characteristics

Name ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Total exact identifications	______
Total acceptable identifications	______
Total incorrect identifications	______
Overall accuracy	______

Directions: Your instructor has tagged a selected group of metals with numbers. Evaluate each metal by its appearance, color, and corrosion characteristics that you can detect by visual examination. Name the **exact** metal if you can, but since some low- to high-carbon products may show limited differences, there may also be **acceptable** identifications.

Metal 1: Appearance ______________________ Color ____________

Corrosion Characteristics: ______________________

Metal 1 Name: ______________________

Metal 2: Appearance ______________________ Color ____________

Corrosion Characteristics: ______________________

Metal 2 Name: ______________________

Metal 3: Appearance ______________________ Color ____________

Corrosion Characteristics: ______________________

Metal 3 Name: ______________________

Assignment Sheet 1

Metal 4: Appearance ______________________________ Color ______________

Corrosion Characteristics: ____

Metal 4 Name: ____

Metal 5: Appearance ______________________________ Color ______________

Corrosion Characteristics: ____

Metal 5 Name: ____

Note: Your instructor may include other metals. In that case, extend you list as required.

Basic Metals and Metallurgy
Unit 4

Job Sheet 1—Conduct Magnet Tests to Identify Common Metals Used for Welding

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Identification of magnetic metals	______
Identification of nonmagnetic metals	______
Overall accuracy	______

A. Equipment and materials

Hand-held magnet
Metal samples as selected and numbered by instructor
Safety glasses
Wooden table or nonmagnetic workspace

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Place metal sample 1 on a wooden or nonmagnetic workspace.

☐ 3. Place the magnet on the metal sample.

☐ 4. Lift the magnet to see if it does or does not stick to metal sample 1.

Note: Remember that a magnet will stick to ferrous metals, but will not stick to nonferrous metals.

☐ 5. Stop and record your findings on the Magnet Test Chart that accompanies this job sheet.

☐ 6. Repeat the procedure for each of the metal samples.

☐ 7. Complete your Magnet Test Chart and turn it in to your instructor for evaluation.

☐ 8. Clean up work area and return tools and materials to proper storage.

Job Sheet 1

Magnet Test Chart

Metal Sample #	Magnetic (Ferrous)	Nonmagnetic (Nonferrous)
1		
2		
3		
4		
5		

Evaluator's comments: ______________________________

____

____

Basic Metals and Metallurgy
Unit 4

Job Sheet 2—Conduct Chisel Tests to Identify Common Metals Used for Welding

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	Rating
Total correct identifications	______
Total incorrect identifications	______
Overall accuracy	______

A. Equipment and materials

Cold chisel
Hammer
Metal samples as selected and numbered by instructor
Safety glasses
Vise

B. Procedure

☐ 1. Put on safety glasses.

☐ 2. Secure metal sample 1 in a vise.

☐ 3. Select a starting point that will provide a sufficient working distance along the sample.

☐ 4. Place the chisel at a 30° to 40° angle over the workpiece and strike the chisel head firmly with a hammer.

Note: Remember to listen for characteristic sounds as you conduct each test.

☐ 5. Strike the chisel as many times as required to establish whether its easy or difficult to chip the metal, and record the information on the Chisel Test Chart that accompanies this job sheet.

Job Sheet 2

☐ 6. Determine whether the chips (or chip) have smooth or rough edges, and record the information on the Chisel Test Chart.

☐ 7. Repeat the procedure for all metal samples.

☐ 8. Complete the Chisel Test Chart and turn it in to your instructor for evaluation.

☐ 9. Clean up area and return tools and materials to proper storage.

Job Sheet 2

Chisel Test Chart

Metal Sample #	Degree of Chipping Difficulty	Size of Chips	Appearance of Chips	Type or Name of Metal
1				
2				
3				
4				
5				

Evaluator's comments: ______________________________

____

____

Basic Metals and Metallurgy
Unit 4

Job Sheet 3—Conduct Spark Tests to Identify Common Metals Used for Welding

Name ________________________ Attempt Number ________

Date ________________________ Overall Rating ________

Evaluation criteria	**Rating**
Total correct identifications	______
Total incorrect identifications	______
Overall accuracy	______

A. Equipment and materials

Locking pliers
Metal samples selected and numbered by instructor
Safety glasses and face shield
Stationary or portable grinder
Wire brush

B. Procedure

☐ 1. Check the work area to make sure flying sparks will not create unsafe condition.

☐ 2. Put on safety glasses and face shield.

☐ 3. Check grinder for the proper rpm of the grinding wheel or disc.

Note: Check with your instructor if you need help checking the rpm.

☐ 4. Clean the grinding wheel with a wire brush, if required.

☐ 5. Move light colored materials away from the grinder in order to create as dark a background as possible for the spark test.

☐ 6. Turn off the light on the grinder, if there is one.

☐ 7. Lock pliers onto metal sample 1, or put the sample in a vise.

Job Sheet 3

☐ 8. Turn grinder on and allow it to reach maximum rpm.

☐ 9. Position yourself at the grinder so that all sparks will be free of obstructions and easy to see.

☐ 10. Place metal sample 1 on the tool rest, hold pliers tightly, and move metal into the grinding wheel until it makes light contact.

☐ 11. Grind metal hard enough and long enough to produce a stable spark pattern.

☐ 12. Observe the color close to the wheel, and the color of the sparks at the dying end of the spark stream.

☐ 13. Observe the shape of the spark pattern or stream pattern.

☐ 14. Observe the volume and length of the spark stream.

☐ 15. Turn stationary or portable grinder off.

☐ 16. Remove metal sample 1.

☐ 17. Record your observations about metal sample 1 on the Spark Identification Chart that accompanies this job sheet.

☐ 18. Repeat the spark testing procedure in order for the remaining number of samples your instructor has selected.

☐ 19. Record your observations for each metal tested.

☐ 20. Complete your Spark Identification Chart and turn it in to your instructor for evaluation.

☐ 21. Clean up area and return tools and materials to proper storage.

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Job Sheet 3

Spark Identification Chart

Metal Sample #	Color	Pattern Shape	Volume	Length in Inches	Name of Metal
1	At wheel: End Stream:				
2	At wheel: End Stream:				
3	At wheel: End Stream:				
4	At wheel: End Stream:				
5	At wheel: End Stream:				

Evaluator's comments: ______________________________

____

____

Basic Math and Measuring
Unit 5

Objective Sheet

Unit Objective

After completing this unit, the student should be able to add, subtract, multiply, and divide fractions and decimal equivalents, convert fractions and decimals from one form to the other, identify graduations on rules, use an English-metric conversion chart, and form angles and lines with a bevel square. The student should demonstrate these competencies by completing the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to basic math and measuring with their correct definitions.
2. Match basic mathematical terms with their definitions.
3. Complete statements about benefits of decimal equivalent charts.
4. Select true statements about benefits of an inches-to-decimal conversion chart.
5. Select true statements about place values of decimal equivalents and ways to express them.
6. Identify types of rules and list examples of their graduations.
7. Arrange in order the steps in reading a scale.
8. Match basic geometric figures with their shapes.
9. Match basic geometric figures with formulas for calculating their areas.
10. Match squares, rectangles, and triangles with formulas for calculating their perimeters.
11. Match circle measurements with formulas for their calculation.
12. Solve problems about English-metric conversion charts and how to use them.

Objective Sheet

13. Solve problems about methods of sizing commonly used steel stock.

14. Add, subtract, multiply, and divide fractions. (Assignment Sheet 1)

15. Add, subtract, multiply, and divide decimal equivalents. (Assignment Sheet 2)

16. Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms. (Assignment Sheet 3)

17. Write fractions as decimals and percent. (Assignment Sheet 4)

18. Write percents as fractions and decimals. (Assignment Sheet 5)

19. Write decimals as fractions and percents. (Assignment Sheet 6)

20. Make conversions with a decimal equivalent chart. (Assignment Sheet 7)

21. Make conversions with an inches-to-decimal conversion chart. (Assignment Sheet 8)

22. Measure distances with 1", ½", and ¼" graduations. (Assignment Sheet 9)

23. Measure distances with ¼" and ⅛" graduations. (Assignment Sheet 10)

24. Measure distances with ⅛" graduations. (Assignment Sheet 11)

25. Measure distances with 1⁄16" graduations. (Assignment Sheet 12)

26. Make conversions with an English-metric conversion chart. (Assignment Sheet 13)

27. Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor. (Job Sheet 1)

28. Form 90° and 45° angles with a combination square and draw parallel lines on metal stock. (Job Sheet 2)

Basic Math and Measuring
Unit 5

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Decimal Equivalent Chart (Objective 3)
   TM 2—Inches-to-Decimal Conversion Chart (Objective 4)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment and job sheets. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

Suggested Activities

14. Give written test.

15. Compile assignment and job sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skill areas have been adapted by MAVCC.

1. Pay particular attention to students who have weak math skills. Arrange to spend extra time with students who have problems with basic math. Pair them up with students who have good math skills so they will not feel they are being singled out. Skill area: **math**.

2. Be sure to have a bevel square, a framing square, a combination square, and a protractor available for use with job sheets 1 and 2. Students need to master the use of a bevel square because they will be required to use it for measuring bevels on groove welds when they begin shielded metal arc welding. Skill area: **learning to learn**.

3. Assignment Sheet 13 presents some basics in the use of an English-metric conversion chart. Several other conversion groups are presented in Teacher Supplement 1. Prepare additional problems for students as you see fit. Conversions of velocity and temperature should be especially useful. Skill areas: **foundation skills** and **math**.

Resources Used in Developing This Unit

1. Fortney, Clarence and Mike Gregory. *Introduction to Welding*. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

2. Olivo and Olivo. *Basic Vocational-Technical Mathematics Fundamentals*. Albany, NY: Delmar Publishers Inc., 1985.

3. Olivo and Olivo. *Basic Vocational-Technical Mathematics*. Albany, NY: Delmar Publishers Inc., 1985.

4. Carmen, Robert A. and Hal M. Saunders. *Mathematics for the Trades*. New York: John Wiley & Sons, 1986.

Suggested Activities

5. St. Paul Area Technical Institute. *Mathematics for Careers: Multiplying and Dividing Whole Numbers.* Albany, NY: Delmar Publishers, 1981.
6. St. Paul Area Technical Institute. *Mathematics for Careers: Fractions.* Albany, NY: Delmar Publishers, 1981.
7. St. Paul Area Technical Institute. *Mathematics for Careers: Measurement and Geometry.* Albany, NY: Delmar Publishers, 1981.

Suggested Supplemental Resources

1. *Teaching Problem-Solving Strategies* by Daniel T. Dolan and James Williamson is a well-illustrate text that presents mathematics in a game-oriented format. The 1983 text was published by Addison Wesley Publishing Company of Reading, Massachusetts, and should be available from a local library or your state vocational department.

2. For math problems of almost any kind, all sorts of guidelines are available in the *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables.* This is a National Bureau of Standards publication edited by Milton Abramowitz and Irene Stegun. The 1972 edition is the tenth printing, it is more than a thousand pages long, and has an extensive index for quick references. A standard in its area, the *Handbook* should be available at most collegiate libraries.

3. A software package from Shopware Educational Systems parallels the rudimentary activities of adding, subtracting, multiplying, and dividing as they are presented in this unit. The program is titled *Vocational Math-Welding* and is available on an Apple, IBM, or Macintosh format. The $79.95 package has a Teacher's Manual which includes additional handout quizzes that can be reproduced for classroom use. The package is available from:

   Software Educational Systems
   101 Hill Road
   Aberdeen, WA 98520-7302
   (206) 532-3392
   (206) 533-5172 (FAX)

Suggested Activities

Instructions For Evaluating Student Performance

When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in either the teacher or student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 - Skilled—Can perform job with no additional training.
3 - Moderately skilled—Has performed job during training program; limited additional training may be required.
2 - Limited skill—Has performed job during training program; additional training is required to develop skill.
1 - Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Basic Math and Measuring
Unit 5

Answers to Assignment Sheets

Assignment Sheet 1

6. a. 1. $1\frac{1}{4}$
    - 2. $2\frac{3}{32}$
    - 3. $12\frac{1}{4}$
   - b. 1. $\frac{1}{8}$
    - 2. $\frac{13}{16}$
    - 3. $1\frac{13}{16}$
   - c. 1. $\frac{15}{32}$
    - 2. $21\frac{1}{4}$
   - d. 1. 2
    - 2. $\frac{1}{2}$

Assignment Sheet 2

6. a. 1. 17.6833
    - 2. 8.86632
    - 3. 25.7563
   - b. 1. 8.722
    - 2. .154
    - 3. 8.875
   - c. 1. 1.6405 or 1.640496
    - 2. 81.7494 or 81.749430
   - d. 1. .0024
    - 2. 3.04833

Assignment Sheet 3

4. a. 1. $1 \div 2 = .500$
    - 2. $5 \div 8 = .625$
    - 3. $1 \div 4 = .250$
    - 4. $1 \div 8 = .125$
    - 5. $5 \div 16 = .3125$
    - 6. $9 \div 16 = .5625$
    - 7. $3 \div 4 = .750$
    - 8. $7 \div 8 = .875$
    - 9. $3 \div 8 = .375$
    - 10. $11 \div 16 = .6875$
   - b. 1. $\frac{3}{8}$
    - 2. $\frac{19}{32}$
    - 3. $2\frac{23}{32}$
    - 4. $\frac{7}{64}$
    - 5. $1\frac{54}{64}$ or $1\frac{27}{32}$

c. 1. $\frac{3}{4}$
   2. $\frac{2}{3}$
   3. $\frac{3}{4}$
   4. $\frac{1}{3}$
   5. $\frac{11}{32}$
   6. $\frac{9}{16}$
   7. $1\frac{7}{56}$
   8. $\frac{5}{8}$
   9. $1\frac{3}{16}$
   10. $\frac{3}{4}$

Assignment Sheet 4

3. a. 1. .125
      2. .25
      3. .50
      4. .75
      5. .625
      6. .35
      7. .4375
      8. .1111---
      9. .444---
      10. .80
   b. 1. 25%
      2. 22.22%. or $22\frac{2}{9}$%
      3. 70%
      4. 75%
      5. 100%
      6. 81.81% or $81\frac{9}{11}$%
      7. 33.33% or $33\frac{1}{3}$%
      8. 44.44% or $44\frac{4}{9}$%
      9. 33.33% or $33\frac{1}{3}$%
      10. 62.5% or $62\frac{1}{2}$%

Assignment Sheet 5

3. a. 1. $\frac{1}{2}$
      2. $\frac{1}{4}$
      3. $\frac{1}{3}$
      4. $\frac{9}{25}$
      5. $\frac{7}{25}$
      6. $\frac{1}{7}$
      7. $\frac{21}{100}$
      8. $\frac{9}{20}$
      9. $\frac{2}{3}$
      10. $\frac{7}{10}$

b. 1. .47
   2. .15
   3. .333
   4. .62
   5. .75
   6. .03
   7. .168
   8. .09
   9. .10
   10. .50

Assignment Sheet 6

3. a. 1. 1/2
      2. 4/5
      3. 7/10
      4. 1/4
      5. 17/25
      6. 11/20
      7. 47/50
      8. 3/8
      9. 7/8
      10. 53/250
   b. 1. 12%
      2. 19%
      3. 70%
      4. 29%
      5. 37%
      6. 42%
      7. 50%
      8. 52.3%
      9. 74.6%
      10. 375%

Assignment Sheet 7

5. a. 1. .0625
      2. .875
      3. .25
      4. .5
      5. .5625
   b. 1. 7/16
      2. 5/16
      3. 3/8
      4. 1/8
      5. 11/16

Answers to Assignment Sheets

Assignment Sheet 8

3. a. 1. 9.56′ or 9.5625′
      2. 3.38′ or 3.3853′
      3. 14.19′ or 14.1866′
      4. 1.5′
   b. 1. 2′ 6″
      2. $8' 7\frac{3}{5}''$
      3. $11' 8\frac{9}{10}''$
      4. $17' 1\frac{3}{10}''$

Assignment Sheet 9

1. a. 4
   b. No
   c. No
   d. 4
   e. No

2. a. No
   b. 5 inches
   c. No
   d. Nearest unit

3. a. 1 inch
   b. 4 inches
   c. 3 inches
   d. Approximate

4. a. No
   b. Yes

5. a. 2
   b. 2½ inches

6. ½, 2½, 3½, 4½

7. a. 2½
   b. 2½ inches

8. a. 4 inches
   b. 4 inches
   c. 1 inch
   d. No

Answers to Assignment Sheets

9. a. 3½ inches
   b. 5 inches
   c. 1½ inches

10. a. ¼
    b. 4

11. 1½, 2¼, 2¾, 3¼, 3½, 4¾

Assignment Sheet 10

1. a. 5¾
   b. ½
   c. 1½
   d. 7¼
   e. 3¼

2. a. 2½
   b. 1¾
   c. 3
   d. 7⅞
   e. $3\frac{3}{16}$ (already in simplest form)

3. a. ¾ inch
   b. 1¼ inches
   c. 2 inches
   d. 2½ inches
   e. 3¼ inches
   f. 4¾ inches

4. a. 4 inches
   b. ½ inch
   c. 4¾ inches
   d. 2¼ inches

5. E

6. a. 8
   b. 2
   c. 16
   d. 4
   e. Half
   f. Fourth
   g. 2
   h. 4

Answers to Assignment Sheets

7. a. 8
   b. Eighths
   c. 8

8. a. 4 7/8
   b. 1/8
   c. 3
   d. 1 1/8
   e. 2 3/8

9. 1/8, 4/8, 5/8, 8/8

10. a. 3 2/4 = 3 4/8
    b. 2 2/8
    c. 3 6/8

11. a. 2 2/4
    b. 2 4/8

Assignment Sheet 11

1. a. 1/8 inch
   b. 1/2 inch
   c. 3/4 inch
   d. 1 1/4 inches
   e. 1 5/8 inches
   f. 1 7/8 inches
   g. 2 3/8 inches
   h. 3 inches
   i. 3 1/2 inches
   j. 3 3/4 inches
   k. 4 1/8 inches
   l. 4 5/8 inches
   m. 5 1/4 inches
   n. 5 5/8 inches

2. a. 1 1/8 inches
   b. 3/8 inch
   c. 5/8 inch
   d. 1/4 inch
   e. 2 1/2 inches
   f. 3 inches
   g. 1 1/8 inches
   h. 1/4 inch
   i. 1/2 inch
   j. 2 1/4 inch

Answers to Assignment Sheets

Assignment Sheet 12

1. a. 16
   b. $\frac{1}{16}$
   c. 16, 8
   d. $\frac{1}{16}$ inch
   e. $3\frac{1}{16}$ inch

2. a. 2
   b. 8
   c. 1
   d. 4
   e. 16

3. a. 16
   b. Sixteenth
   c. 16
   d. 8

4. a. Yes
   b. No
   c. Yes
   d. Yes
   e. No
   f. Yes
   g. No

5. a. $\frac{1}{16}$, $\frac{5}{16}$, $\frac{7}{16}$, $\frac{9}{16}$, $\frac{11}{16}$, $\frac{15}{16}$
   b. $3\frac{4}{8}$, $3\frac{2}{4}$, $3\frac{1}{2}$

6. a. $\frac{1}{8}$
   b. $\frac{3}{4}$ and $\frac{6}{8}$
   c. $\frac{2}{2}$, $\frac{4}{4}$, $\frac{8}{8}$, $\frac{16}{16}$
   d. $\frac{3}{8}$
   e. $\frac{5}{8}$
   f. $\frac{3}{4}$
   g. Zero
   h. Yes

7. a. 16ths
   b. $\frac{5}{16}$
   c. $\frac{5}{16}$
   d. $3\frac{5}{16}$ inches
   e. $4\frac{5}{16}$ inches

Answers to Assignment Sheets

8.
    a. $1\frac{9}{16}$ inches
    b. $2\frac{7}{8}$ inches
    c. $3\frac{1}{2}$ inches
    d. $4\frac{3}{16}$ inches

9.
    a. 2 inches
    b. 2 inches
    c. $1\frac{3}{4}$ inches
    d. $1\frac{7}{8}$ inches
    e. $1\frac{13}{16}$ inches
    f. E

Assignment Sheet 13

1. 0.0396875 centimeters
2. 4.88 meters
3. 6.6 pounds
4. 39.6 pounds

Basic Math and Measuring
Unit 5

Answers to Written Test

1. a. 7
   b. 4
   c. 9
   d. 12
   e. 5
   f. 1
   g. 11
   h. 10
   i. 2
   j. 6
   k. 13
   l. 3
   m. 8

2. a. 4
   b. 7
   c. 9
   d. 11
   e. 1
   f. 5
   g. 12
   h. 14
   i. 2
   j. 13
   k. 8
   l. 3
   m. 6
   n. 10

3. a. Quick reference
   b. Greater accuracy
   c. Decimals into fractions

4. b

5. a, c

6. a. Decimal rule: Tenths, hundredths, thousands
   b. Metric rule: Meter, decimeter, centimeter, millimeter
   c. Fractional rule: Eighths, sixteenths, thirty-seconds, sixty-fourths

   Note: Any two graduations are acceptable for each rule.

7. a. 3
   b. 2
   c. 4
   d. 1

8. a. 3
   b. 5
   c. 2
   d. 6
   e. 1
   f. 4

Answers to Written Test

9. a. 6
b. 4
c. 2
d. 1 of 5
e. 5 or 1
f. 3

10. a. 2
b. 1
c. 3

11. a. 2
b. 4
c. 3
d. 1

12. a. 2
b. 1
c. 1

13. a. 3
b. 2
c. 1
d. 2
e. 1

Basic Math and Measuring
Unit 5

Written Test

Name ______________________________ Score ____________

1. Match the terms on the right with their correct definitions.

______ a. Area, the measurement of surface inside a figure

______ b. Base

______ c. The measurement of volume

______ d. A system of measurement based on feet and pounds

______ e. Subdivisions on a measuring device

______ f. Height

______ g. Length

______ h. A system of measurement based on meters and kilograms

______ i. Perimeter, the distance around a flat surface

______ j. A letter from the Greek alphabet used to indicate the ratio of the circumference of a circle to its diameter

______ k. The measurement of area

______ l. Numbers which appear below a line to clarify a reference

______ m. Numbers which appear about a line to indicate the degree of increase in power

1. H or h
2. P or p
3. Sublinear numbers
4. B or b
5. Graduations
6. Pi or π
7. A or a
8. Superlinear numbers
9. Cubic measure
10. Metric System
11. L or l
12. English System
13. Square measure

Written Test

2. Match basic mathematical terms with their definitions.

_____a. Any number or numbers used to indicate an entire unit, quantity, or amount

_____b. Two numbers consisting of a numerator and denominator separated by a fraction line to indicate a part of one unit

_____c. Any whole number plus a fractional part of one additional unit

_____d. The top number of a fraction

_____e. The bottom number of a fraction

_____f. A fraction whose numerator is less than the denominator, indicating a value of less than one unit

_____g. A fraction whose numerator is equal to or greater than the denominator, indicating a value greater than one unit

_____h. A proper fraction with a numerator of 1

_____i. A fraction with either or both terms expressed as a fraction or mixed number

_____j. The lowest based number (numerator and denominator) by which a fraction may be reduced for simplification in unit measurement

_____k. Two fractions with the same denominator in each fraction

_____l. The parts of a number than can be multiplied to equal that number

_____m. The result of addition

_____n. The result of division

1. Denominator
2. Complex fraction
3. Factors
4. Whole number
5. Proper fraction
6. Sum
7. Fraction
8. Common denominator
9. Mixed number
10. Quotient
11. Numerator
12. Improper fraction
13. Lowest terms
14. Unit fraction

Written Test

3. Complete statements about benefits of decimal equivalent charts. Circle the material that best completes each statement.

    a. Decimal equivalent charts provide a (**scientific way**) (**quick reference**) for converting fractions to decimals.

    b. Converting fractions to decimals provides (**faster time**) (**greater accuracy**) in measuring.

    c. The decimal equivalent chart is also handy for converting (**decimals into fractions**) (**feet into inches**), if the information is required.

4. Select true statements about benefits of an inches-to-decimal conversion chart. Place an "X" beside each true statements.

______a. Converting inches on a rule into decimal form is much slower when you use an inches-to-decimal chart, but it is much more accurate.

______b. An inches-to-decimal conversion chart provides an easy reference for adding, subtracting, multiplying, and dividing parts of a linear measurement.

______c. An inches-to-decimal conversion chart can also be used for finding feet and inches by simple subtraction.

5. Select true statements about place values of decimal equivalents and ways to express them. Place an "X" beside each statement that is true.

Note: For a statement to be true, all parts of the statement must be true.

______a. Decimal equivalents have place values related to their position in front of or beyond the decimal point.

    (1) The place value to the immediate left of the decimal point is the unit.
    (2) The place value to the immediate right of the decimal is tenths of a unit.
    (3) The place value two places right from the decimal is hundredths of a unit.
    (4) The place value three places right from the decimal is thousandths of a unit.
    (5) The place value four places right from the decimal is ten thousands of a unit.

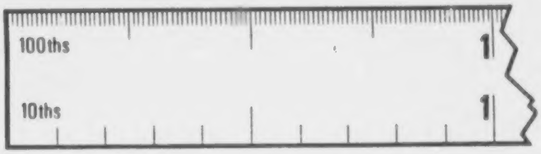
______b. Decimal equivalents must be written.

______c. Decimal equivalents may be written as numbers that combine numerators, denominators, whole numbers, mixed numbers and other forms to express a value.

Written Test

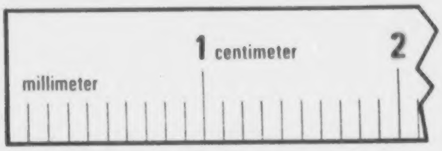
6. Identify types of rules and list at least two examples of their graduations.

a. Rule name: ____________________


100ths
1
10ths
1

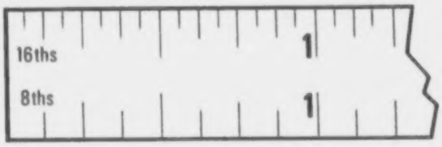
Graduations: ____

b. Rule name: ____________________


1 centimeter
2
millimeter

Graduations: ____

c. Rule name: ____________________


16ths
1
8ths
1

Graduations: ____

7. Arrange in order the steps in reading a scale. Place a "1" beside the first step, a "2" by the second step, and place the other steps in order.

______a. Total the number of graduations.

______b. Count whole units.

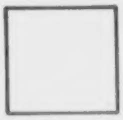
______c. Reduce graduations to lowest terms.

______d. Select proper scale.

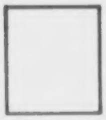
Written Test

8. Match basic geometric figures with their shapes. Place the number of the figure in the blank beside the appropriate shape.

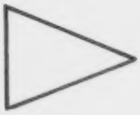
______a.



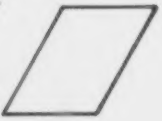
______b.



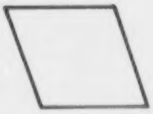
______c.



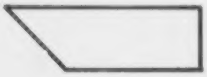
______d.



______e.



______f.



1. Rhombus
2. Triangle
3. Square
4. Trapezoid
5. Rectangle
6. Parallelogram

Written Test

9. Match basic geometric figures with formulas for calculating their areas. Place the number of the figure in the blank beside the appropriate formula.

_____a. $A = s^2$

_____b. $A = lw$

_____c. $A = \frac{1}{2}bh$

_____d. $A = bh$

_____e. $A = bh$

_____f. $A = \frac{1}{2}h(b_1 + b_2)$

1. Parallelogram
2. Triangle
3. Trapezoid
4. Rectangle
5. Rhombus
6. Square

10. Match squares, rectangles, and triangles with formulas for calculating their perimeters. Place the number of the figure in the blank beside the appropriate formula.

_____a. $P = 4s$

_____b. $P = 2L = 2W$

_____c. $P = s_1 + s_2 + s_3$

1. Rectangle
2. Square
3. Triangle

11. Match circle measurements with formulas for their calculation. Place the number of the formula in the blank beside the measurement definition.

_____a. The diameter of a circle is equal to two times the radius.

_____b. The radius of a circle is equal to half its diameter.

_____c. The circumference of a circle is approximately equal to the diameter times 3.14 or π.

_____d. The area of a circle is equal to the square of the radius times 3.14 or π.

1. $A = R^2$
2. $D = 2R$
3. $C = 3.14D$
4. $R = D/2$

Written Test

12. Solve problems about English-Metric conversion charts and how to use them. Circle the best answer for each of the following situations.

    a. If you knew that the conversion factors were 25.4 and you wanted to convert 12 inches to millimeters, you should:

        (1) Divide 25.4 by 12 to get 2.1 millimeters.
        (2) Multiply 12 by 25.4 to get 304.8 millimeters.

    b. If you needed to convert meters into feet, you should:

        (1) Simply find the conversion factor on an English-metric conversion chart, then multiply the meters by the conversion factor.
        (2) Use an English-metric conversion chart to find the conversion factor for feet, then multiply the feet by the conversion factor.

    c. In all cases, the conversion factor should be used to:

        (1) Multiply.
        (2) Divide.
        (3) Multiply or divide as the situation requires.

13. Solve problems about methods of sizing commonly used steel stock. Circle the best answer to each of the following situations.

    a. Square bars, cold-rolled flat bars, and hot-rolled strips are usually sized by:

        (1) Thickness and length
        (2) Width and length
        (3) Width, thickness, and length

    b. When measuring a structural W beam, width has special significance because it refers to:

        (1) The width of the rising member
        (2) The width of the flange

    c. When measuring both structural W and structural S beams, T has a special significance because it refers to:

        (1) The thickness of the web
        (2) The thickness of the flange

Written Test

d. The flange width in bar and structural tees is indicated by the:

   (1) Letter W
   (2) Letter F

e. The basic difference between measuring hot-rolled half ovals and hot and cold-rolled rounds is that:

   (1) Half ovals should have the width measured at their base and rounds should have their diameter measured because that is the width
   (2) One is measured by the diameter at its base, the other by the diameter at its middle

***Permission to duplicate this test is granted.**

Basic Math and Measuring
Unit 5

Unit Evaluation Form

Student Name ______________________ Unit Rating __________

Assignment Sheet 1—Add, Subtract, Multiply, and Divide Fractions Rating ______

Comments: ______________________________________

____

Assignment Sheet 2—Add, Subtract, Multiply, and Divide Decimal Equivalents Rating ______

Comments: ______________________________________

____

Assignment Sheet 3—Convert Fractions to Decimal Form, Change Fractions to a Common Denominator, and Reduce Fractions to Lowest Terms Rating ______

Comments: ______________________________________

____

Assignment Sheet 4—Write Fractions as Decimals and Percents Rating ______

Comments: ______________________________________

____

Assignment Sheet 5—Write Percents as Fractions and Decimals Rating ______

Comments: ______________________________________

____

Assignment Sheet 6—Write Decimals as Fractions and Percents Rating ______

Comments: ______________________________________

____

Assignment Sheet 7—Make Conversions with a Decimal Equivalent Chart Rating ______

Comments: ______________________________________

____

Unit Evaluation Form

Assignment Sheet 8—Make Conversions with an Inches-to-Decimal Conversion Chart Rating ______

Comments: ____

____

Assignment Sheet 9—Measure Distances with 1″, ½″, and ¼″ Graduations Rating ______

Comments: ____

____

Assignment Sheet 10—Measure Distances with ¼″ and ⅛″ Graduations Rating ______

Comments: ____

____

Assignment Sheet 11—Measure Distances with ⅛″ Graduations Rating ______

Comments: ____

____

Assignment Sheet 12—Measure Distances with 1/16″ Graduations Rating ______

Comments: ____

____

Assignment Sheet 13—Make Conversions with an English-Metric Conversion Chart Rating ______

Comments: ____

____

Job Sheet 1—Adjust a Bevel Square to a 45° Angle Using a Framing Square, a Combination Square, and a Protractor Rating ______

Comments: ____

____

Job Sheet 2—Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock Rating ______

Comments: ____

____

Unit Evaluation Form

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

____

Teacher Signature ____________________ Date __________

Student Signature ____________________ Date __________

*Permission to duplicate this form is granted.

Basic Math and Measuring
Unit 5

Teacher Supplement 1—English-Metric Conversions

Some of the welding certification tests administered by the American Welding Society require the applicant to convert metric measurements to English measurements. Objective 12 and Assignment Sheet 13 of this unit introduce the student to two basic conversion procedures, one for length and one for weight. The English-metric conversion charts included with this supplement are presented for reference. If students appear to require more instruction in the conversion procedure, items may be quickly prepared from the conversion charts.

	When Your Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
AREA	Inches^2	Millimeters^2 (mm^2)	645.2
	Millimeters^2	Inches^2	0.0016
	Inches^2	Centimeters^2 (cm^2)	6.45
	Centimeters^2	Inches^2	0.16
	Foot^2	Meters^2 (m^2)	0.093
	Meters^2	Foot^2	10.76

Teacher Supplement 1

	When Your Know	You Can Convert To	When You Multiply By the Conversion Factor
ACCELERATION	Inch/Sec^2	Meter/Sec^2	0.0254
	Meter/Sec^2	Inch/Sec^2	39.37
	Foot/Sec^2	Meter/Sec^2 (m/s^2)	0.3048
	Meter/Sec^2	Foot/Sec^2	3.280
TORQUE	Pound-Inch (Inch-Pound)	Newton-Meters (N-M)	0.113
	Newton-Meters	Pound-Inch	8.857
	Pound-Foot (Foot-Pound)	Newton-Meters	1.356
	Newton-Meters	Pound-Foot	0.737
PRESSURE	Pound/sq. in. (PSI)	Kilopascals (kPa)	6.895
	Kilopascals	Pound/sq. in.	0.145
	Inches of Mercury (Hg)	Kilopascals	3.377
	Kilopascals	Inches of Mercury (Hg)	0.296
FUEL PERFORMANCE	Miles/gal	Kilometers/liters (km/l)	0.425
	Kilometers/liters	Miles/gal	2.352
VELOCITY	Miles/hour	Kilometers/hr (km/h)	1.609
	Kilometers/hour	Miles/hour	0.621
TEMPERATURE	Degrees Fahrenheit	Degrees Celsius	5/9 (F° −32)
	Degrees Celsius	Degrees Fahrenheit	9/5 (C°) +32 = F°
CAPACITY-VOLUME	Ounces	Milliliters (ml)	30.
	Milliliters	Ounces	0.034
	Pints	Liters (l)	0.47
	Liters	Pints	2.1
	Quarts	liters	0.95
	Liters	Quarts	1.06
	Gallons	Liters	3.8
	Liters	Gallons	0.26
	Cubic Inches	Liters	0.0164
	Liters	Cubic Inches	61.03
	Cubic Inches	Cubic Centimeters (cc)	16.39
	Cubic Centimeters	Cubic Inches	0.061
WEIGHT (MASS)	Ounces	Grams	28.4
	Grams	Ounces	0.035
	Pounds	Kilograms	0.45
	Kilograms	Pounds	2.2
FORCE	Ounce	Newtons (N)	0.278
	Newtons	Ounces	35.98
	Pound	Newtons	4.448
	Newtons	Pound	0.225
	Newtons	Kilograms (kg)	0.102
	Kilograms	Newtons	9.807

Decimal Equivalent Chart

$\frac{1}{64}$	.015625
$\frac{1}{32}$	.03125
$\frac{3}{64}$	.046875
$\frac{1}{16}$	.0625
$\frac{5}{64}$	.078125
$\frac{3}{32}$	.09375
$\frac{7}{64}$	.109375
$\frac{1}{8}$	.125
$\frac{9}{64}$	.140625
$\frac{5}{32}$	.15625
$\frac{11}{64}$	.171875
$\frac{3}{16}$	.1875
$\frac{13}{64}$	.203125
$\frac{7}{32}$	.21875
$\frac{15}{64}$	.234375
$\frac{1}{4}$	.25
$\frac{17}{64}$	.265625
$\frac{9}{32}$	.28125
$\frac{19}{64}$	.296875
$\frac{5}{16}$	.3125
$\frac{21}{64}$	.328125
$\frac{11}{32}$	.34375
$\frac{23}{64}$	.359375
$\frac{3}{8}$	.375
$\frac{25}{64}$	.390625
$\frac{13}{32}$	.40625
$\frac{27}{64}$	.421875
$\frac{7}{16}$	.4375
$\frac{29}{64}$	.453125
$\frac{15}{32}$	.46875
$\frac{31}{64}$	.484375
$\frac{1}{2}$	.5
$\frac{33}{64}$	.515625
$\frac{17}{32}$	.53125
$\frac{35}{64}$	.546875
$\frac{9}{16}$	.5625
$\frac{37}{64}$	.578125
$\frac{19}{32}$	.59375
$\frac{39}{64}$	.609375
$\frac{5}{8}$	.625
$\frac{41}{64}$	.640625
$\frac{21}{32}$	.65625
$\frac{43}{64}$	.671875
$\frac{11}{16}$	.6875
$\frac{45}{64}$	.703125
$\frac{23}{32}$	.71875
$\frac{47}{64}$	.734375
$\frac{3}{4}$	.75
$\frac{49}{64}$	.765625
$\frac{25}{32}$	.78125
$\frac{51}{64}$	.796875
$\frac{13}{16}$	.8125
$\frac{53}{64}$	.828125
$\frac{27}{32}$	.84375
$\frac{55}{64}$	.859375
$\frac{7}{8}$	.875
$\frac{57}{64}$	.890625
$\frac{29}{32}$	.90625
$\frac{59}{64}$	.921875
$\frac{15}{16}$	.9375
$\frac{61}{64}$	.953125
$\frac{31}{32}$	.96875
$\frac{63}{64}$	.984375
1	1.

Inches-to-Decimal Conversion Chart

Fractions of Inches	
1/16″	.0052
3/32″	.0078
1/8″	.0104
5/32″	.0130
3/16″	.0156
7/32″	.0182
1/4″	.0208
9/32″	.0234
5/16″	.0260
3/8″	.0313
7/16″	.0364
1/2″	.0417
9/16″	.0468
5/8″	.0521
11/16″	.0572
3/4″	.0625
13/16″	.0677
7/8″	.0726
15/16″	.0781

Inches	
1″	.0833
2″	.1667
3″	.2500
4″	.3333
5″	.4167
6″	.5000
7	.5833
8″	.6667
9″	.7500
10″	.8333
11″	.9167
12″	1.0000

Note: Do not confuse inches-to-decimal with decimal equivalents.

Basic Math and Measuring
Unit 5

Information Sheet

1. **Terms and definitions**

   a. **A or a** — Area, the measurement of surface inside a figure

   b. **B or b** — Base

   c. **Cubic measure** — The measurement of volume

   d. **English System** — A system of measurement based on feet and pounds

   e. **Graduations** — Subdivisions on a measuring device

   f. **H or h** — Height

   g. **L or l** — Length

   h. **Metric System** — A system of measurement based on meters and kilograms

   i. **P or p** — Perimeter, the distance around a flat surface

   j. **PI or π** — A letter from the Greek alphabet used to indicate the ratio of the circumference of a circle to its diameter

   Note: Pi is 3.14 or sometimes carried to 3.1416 or further for critical measurements.

   k. **Square measure** — The measurement of area

   l. **Sublinear numbers** — Numbers which appear below a line to clarify a reference

   Examples: b_1 means base one, and L_2 means length two

   m. **Superlinear numbers** — Numbers which appear above a line to indicate the degree of increase in power

   Examples: R^2 means radius square and 10^3 means ten to the third power, 10 × 10 × 10 or 1,000

Information Sheet

2. Basic mathematical terms and their definitions

a. **Whole number** — Any number or numbers used to indicate an entire unit, quantity, or amount

Examples: 1, 3, 10, 25

b. **Fraction** — Two numbers consisting of a numerator and denominator separated by a fraction line to indicate a part of one unit

Examples: $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$

c. **Mixed number** — Any whole number plus a fractional part of one additional unit

Examples: $1\frac{1}{8}$, $3\frac{1}{4}$, $5\frac{1}{2}$, $6\frac{3}{4}$

d. **Numerator** — The top number of a fraction

Example: The numerator of $\frac{1}{3}$ is 1

e. **Denominator** — The bottom number of a fraction

Example: Denominator of $\frac{3}{4}$ is 4

f. **Proper fraction** — A fraction whose numerator is less than the denominator, indicating a value of less than one unit

Examples: $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{8}$, $\frac{9}{16}$

g. **Improper fraction** — A fraction whose numerator is equal to or greater than the denominator, indicating a value greater than one unit

Examples: $\frac{9}{8}$, $\frac{18}{16}$, $\frac{3}{2}$, $\frac{7}{4}$

h. **Unit fraction** — A proper fraction with a numerator of 1

Examples: $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{2}$

Information Sheet

i. **Complex fraction** — A fraction with either or both terms expressed as a fraction or mixed number

Examples: $\frac{7}{1/16}$ $\frac{5\frac{1}{2}}{2\frac{3}{4}}$

j. **Lowest terms** — The lowest base number (numerator and denominator) by which a fraction may be reduced for simplification in unit measurement

Example: $\frac{12}{16} = \frac{6}{8} = \frac{3}{4}$ which is the lowest term

k. **Common denominator** — Two fractions with the same denominator in each fraction (proper or improper) to permit simplification in adding and dividing fractions

Example: $\frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} = \frac{8}{64} + \frac{4}{64} + \frac{2}{64} + \frac{1}{64} = \frac{15}{64}$

l. **Factors** — The parts of a number that can be multiplied to equal that number

Examples: 2 and 5 are factors of 10 because 2 × 5 = 10; 6 and 2 and 3 and 4 are factors of 12 because 6 × 2 = 12 and 3 × 4 = 12

m. **Sum** — The result of addition

Example: 4 is the sum of 2 + 2

n. **Quotient** — The result of division

Example: 2 is the quotient of 4 ÷ 2

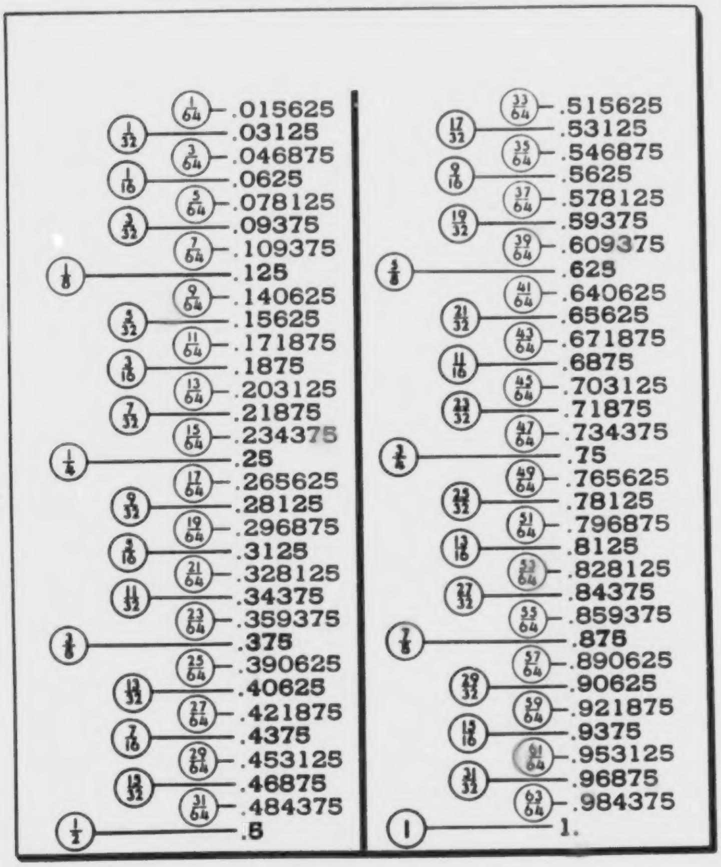
3. **Benefits of decimal equivalent charts**

   a. Decimal equivalent charts provide a quick reference for converting fractions to decimals.

   b. Converting fractions to decimals provides greater accuracy in measuring.

Information Sheet

Decimal Equivalent Chart



1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

c. The decimal equivalent chart is also handy for converting decimals into fractions, if such information is required.

4. **Benefits of an inches-to-decimal conversion chart**

   a. Converting inches on a rule into decimal form is much faster when you use an inches-to-decimal chart.

   b. An inches-to-decimal conversion chart provides an easy reference for adding, subtracting, multiplying, or dividing parts of a linear measurement.

Information Sheet

Inches-to-Decimal Conversion Chart

Fractions of Inches		Inches	
1/16″	.0052	1″	.0833
3/32″	.0078		
1/8″	.0104	2″	.1667
5/32″	.0130		
3/16″	.0156	3″	.2500
7/32″	.0182		
1/4″	.0208	4″	.3333
9/32″	.0234		
5/16″	.0260	5″	.4167
3/8″	.0313		
7/16″	.0364	6″	.5000
1/2″	.0417		
9/16″	.0468	7	.5833
5/8″	.0521		
11/16″	.0572	8″	.6667
3/4″	.0625		
13/16″	.0677	9″	.7500
7/8″	.0726		
15/16″	.0781	10″	.8333
		11″	.9167
		12″	1.0000

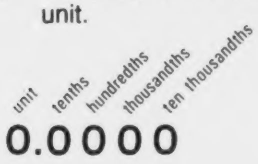
c. An inches-to-decimal conversion chart can also be used for finding feet and inches by simple addition.

Note: Do not confuse inches-to-decimal with decimal equivalents.

5. Place values of decimal equivalents and ways to express them

a. Decimal equivalents have place values related to their position in front of or beyond the decimal point.

(1) The place value to the immediate left of the decimal point is the unit.
(2) The place value to the immediate right of the decimal is tenths of a unit.
(3) The place value two places right from the decimal is hundredths of a unit.
(4) The place value three places right from the decimal is thousandths of a unit.
(5) The place value four placed right from the decimal is ten thousands of a unit.



Information Sheet

b. Decimal equivalents may be spoken or written as words.

Example: To hundred fifty thousandths

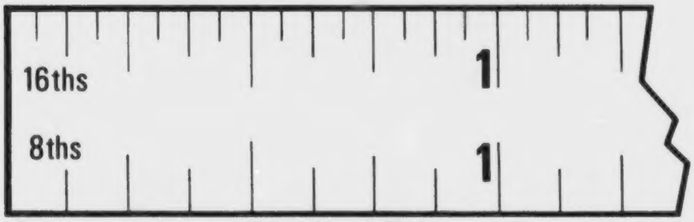
c. Decimal equivalents may be written as numbers that combine numerators, denominators, whole numbers, mixed numbers, and other forms to express a value.

Example: $^{21}/_{64}$ = 0.3281

6. Types of rules and their graduations

a. Fractional:

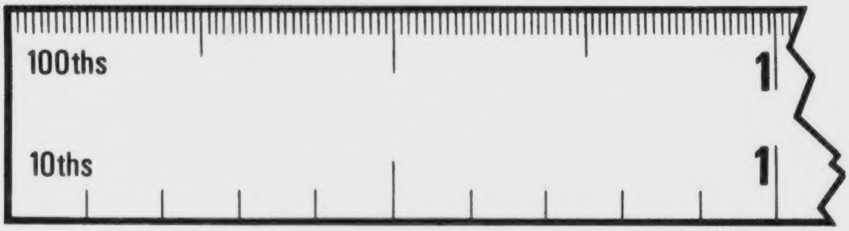
(1) Eighths ($^{1}/_{8}$″)
(2) Sixteenths ($^{1}/_{16}$″)
(3) Thirty-seconds ($^{1}/_{32}$″)
(4) Sixty-fourths ($^{1}/_{64}$″)



Fractional Rule

b. Decimal:

(1) Tenths (0.1)
(2) Hundredths (0.01)
(3) Thousands (0.001)

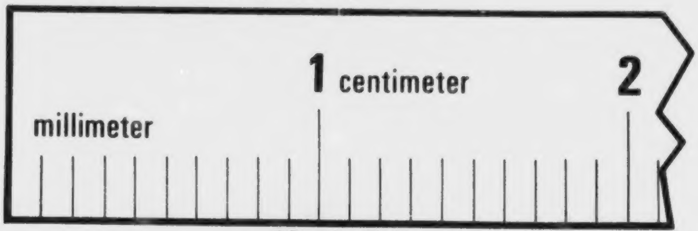


Decimal Rule

Information Sheet

c. Metric:

(1) Meter (1.0m)
(2) Decimeter (0.1m)
(3) Centimeter (0.01m)
(4) Millimeter (0.001m)



Metric Rule

7. **Steps for reading a rule**

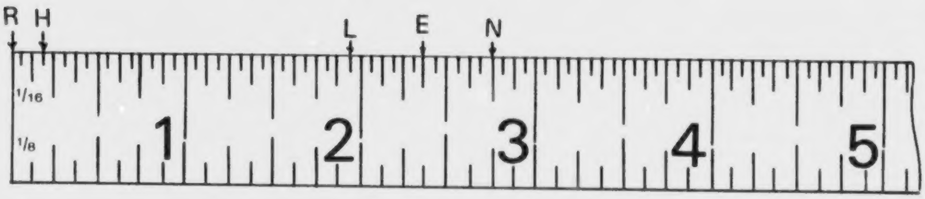
a. Select proper scale.

b. Count whole units.

c. Total the number of graduations.

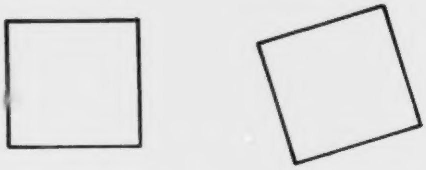
d. Reduce graduations to lowest terms.

Example: When measuring the distance from R to E in the following illustration, the third mark past 2" indicates it is the ⅛" scale, there are two whole units, two full inches preceding the fractional measure, and there are ⁶⁄₁₆ graduations following the whole units; ½ should be reduced to the lowest terms, and the measurement from R to E is 2⅜".

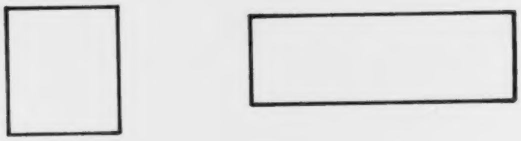


8. Basic geometric figures and their shapes

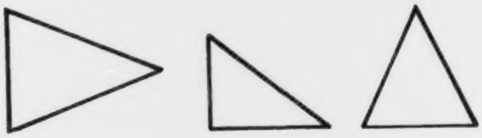
a. Square



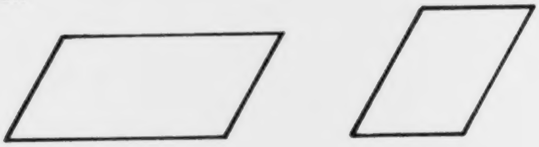
b. Rectangle



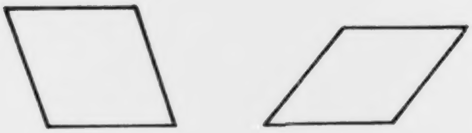
c. Triangle



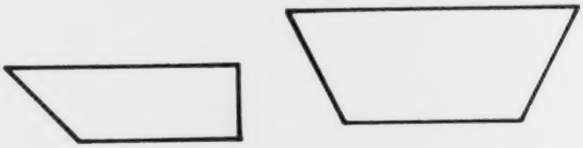
d. Parallelogram



e. Rhombus



f. Trapezoid



Information Sheet

9. **Basic geometric figures and formulas for calculating their areas**

   a. Square — A = s^2

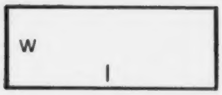
      Example:

      s = 10′

      A = s^2
      A = 10 × 10
      A = 100 square feet

   b. Rectangle — A = 1w

      Example:



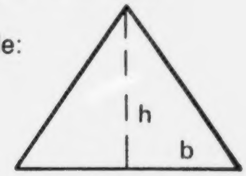
      2 yards

      9 yards

      A = l × w
      A = 9 × 2
      A = 18 square yards

   c. Triangle — A = ½ bh

      Example:



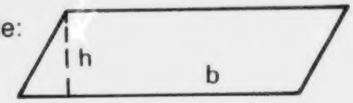
      b = 12″, h = 7″

      A = ½ bh
      A = ½ × 12 × 7
      A = 6 × 7
      A = 42 square inches

Information Sheet

d. Parallelogram — $A = bh$

Example:

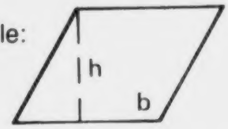


$b = 12''$, $h = 7''$

$A = bh$
$A = 12 \times 7$
$A = 84$ square inches

e. Rhombus — $A = bh$

Example:

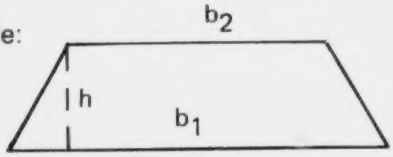


$b = 9$ mile, $h = 2\frac{1}{3}$ miles

$A = bh$
$A = 9 \times 2\frac{1}{3}$
$A = \frac{9}{1} \times \frac{7}{3}$
$A = \frac{63}{3}$
$A = 21$ square miles

f. Trapezoid — $A = \frac{1}{2}h\ (b_1 + b_2)$

Example:



$h = 7''$, $b_1 = 8''$, $b_2 = 5''$

$A = \frac{1}{2}h\ (b_1 + b_2)$
$A = (\frac{1}{2} \times 7)\ (8 + 5)$
$A = (\frac{7}{2})\ (13)$
$A = \frac{7}{2} \times \frac{13}{1}$
$A = \frac{91}{2}$
$A = 45\frac{1}{2}$ square inches

Note: When measuring area, the result will always be square inches, square feet, or square whatever quantity is being measured.

Information Sheet

10. Squares, rectangles, and triangles and formulas for calculating their perimeters

a. Square — $P = 4s$

Example: The length of a side of a square is 6″

$P = 4s$
$P = 4 \times 6''$
$P = 24''$

b. Rectangle — $P = 2L + 2W$

Example: The length of a rectangle is 4′ and the width is 3′

$P = 2L + 2W$
$P = (2 \times 4') + (2 \times 3')$
$P = 8' + 6'$
$P = 14'$

c. Triangle — $P = s_1 + s_2 + s_3$

Example: A triangle has sides of 2′, 3′, and 8′

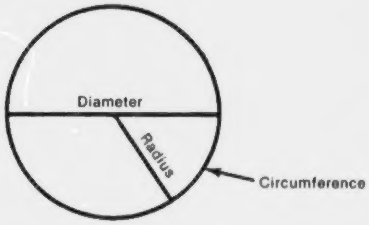
$P = s_1 + s_2 + s_3$
$P = 2' + 3' + 8'$
$P = 13'$

11. Circle measurements and formulas for their calculation

a. $D = 2R$ — The diameter of a circle is equal to two times the radius.

b. $R = D/2$ — the radius of a circle is equal to half its diameter.

c. $C = 3.14D$ — The circumference of a circle is approximately equal to the diameter times 3.14 or π.



Information Sheet

12. English-metric conversion charts and how to use them

Note: Because almost all overseas supplies used in American industry are measured on the metric system, the ability to convert metric to English measurement is becoming a common workplace requirement.

a. English-metric conversion charts provide a handy conversion factor for converting metrics to English and English to metrics.

b. To use an English-metric conversion chart, identify the English measurement, the metric form you want to convert it to, and then multiply the English measurement by the proper conversion factor.

Example: If you want to know what 10 inches would be in metrics, multiply 10 × 25.4 (the conversion factor) to get 254 millimeters.

c. To use an English-metric conversion chart, identify the metric measurement, the English form you want to convert it to, and then multiply the metric measurement by the proper conversion factor.

Example: If you want to know what 254 millimeters would be in English, multiply 254 × 0.04 to get 10 inches (the figure is actually 10.1, but it should be rounded off to 10).

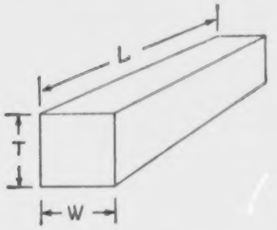
	When Your Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
AREA	Inches^2	Millimeters^2 (mm^2)	645.2
	Millimeters^2	Inches^2	0.0016
	Inches^2	Centimeters^2 (cm^2)	6.45
	Centimeters^2	Inches^2	0.16
	Foot^2	Meters^2 (m^2)	0.093
	Meters^2	Foot^2	10.76

Information Sheet

13. Methods of sizing commonly used steel stock

a. Square bars are sized according to thickness, width, and length.

Example:



W = Width

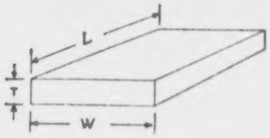
T = Thickness
1/4" to 2-3/4", in graduations of 1/16" and 1/8".

L = Length — 16', 20', 36'.

Courtesy Lincoln Electric Company

b. Hot and cold-rolled flat bars are sized according to thickness, width, and length.

Example:



T = Thickness
1/4" to 1/2" in graduations of 1/16".
1/2" to 1-1/4" in graduations of 1/8".
1-1/4" to 2' in graduations of 1/4".
(3/16" and lighter, see Strips)

W = Width — 3/8" to 6" in graduations of 1/8" to 1/4".

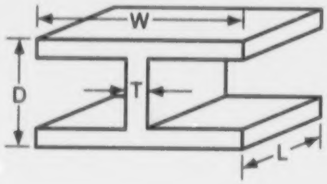
L = Length — 16', 36'.

Courtesy Lincoln Electric Company

c. Structural W beams are sized according to depth, width of flange, web thickness, and length.

Note: Structural W beams are also called wide-flange beams to indicate that they are wide-flange beams, and the surfaces of the inside and outside flanges are parallel with each other.

Example:



D = Depth (size)
4", 5", 6" and larger
W = Width of flange
T = Thickness of web
S = Length

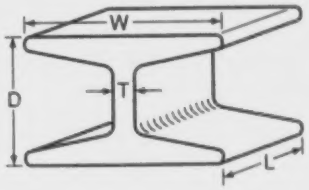
Courtesy Lincoln Electric Company

Information Sheet

d. Structural S beams are sized according to depth, width of flange, web thickness, and length.

Note: Structural S beams are also called standard beams or I beams, and are relatively easy to distinguish from wide-flange beams because the inside surface of the flange is sloped approximately 10 degrees.

Example:

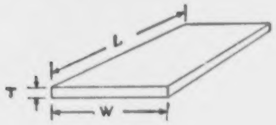


D = Depth (size)
3", 4", 5", and larger
W = Width of flange
T = Thickness of web
L = Length

Courtesy Lincoln Electric Company

e. Hot rolled strips 3⁄16″ or less in thickness are sized according to thickness, width, and length

Example:



T = Thickness — (thickness measurement expressed in fractions of an inch and gauge number).
3/16" (.1875")
No. 10 (.134"); 1/8" (.125");
No. 12 (.109"); No. 14 (.083");
No. 16 (.065"); No. 18 (.049");
No. 20 (.035"); No. 22 (.028").

W = Width
3/8" to 2" in graduations of 1/8".
2" to 3-1/2" in graduations of 1/4".
3-1/2" to 6" in graduations of 1/2".
6" to 12" in graduations of 1".

L = Length — 14' to 16".

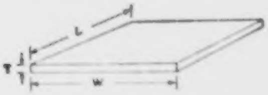
Courtesy Lincoln Electric Company

Information Sheet

f. Hot and cold-rolled sheets are sized according to width and length with thickness indicated by F to indicate 3/16″ and less by gauge number.

Note: Rolled steel 3/16″ or less is classified as sheet, and over 3/16″ is classified as plate.

Example:



F = Thickness — 3/16" and less expressed
according to gauge number.
3/16"
No. 8 (.1644"); No. 10 (.1345");
No. 11 (.1196"); No. 12 (.1046");
No. 14 (.0747"); No. 16 (.0598");
No. 18 (.0478"); No. 20 (.0359");
No. 22 (.0299"); No. 24 (.0239");
No 26 (.0179"); No. 28 (.0149").

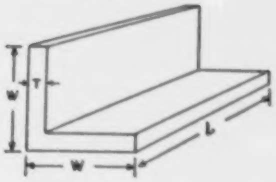
W = Width — measurements given in inches —
30", 36", 42", 48", 54", 60", 72", 84".

L = Length — measurements given in inches —
96", 120", 144", 156", 240".

Courtesy Lincoln Electric Company

g. Bar and structural angles are sized according to width times width (both angles) times thickness and length.

Example:



W = Width of legs
1/2" to 1-1/2" in graduations of 1/8" of flange.
1-1/2" to 2-1/2" in graduations of 1/4".
3" and over structural steel.

T = Thickness of leg 1/8" to 1/2" in graduations
of 1/16".

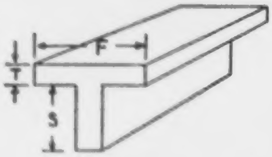
Angle stock is manufactured in equal or unequal width of legs,
Example: 2-1/2" x 1-1/2" or 2" x 2".

L = Length — 16', 18', 20'.

Courtesy Lincoln Electric Company

h. Bar and structural tees are sized according to flange width, stem width, thickness, and length.

Example:



F = Flange width
3/4" to 2-1/2" in graduations of 1/4".

S = Stem width
3/4" to 2-1/2" in graduations of 1/4".

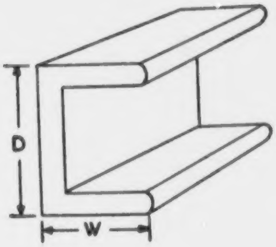
T = Thickness
1/8" to 3/8" in graduations of 1/16".

Courtesy Lincoln Electric Company

Information Sheet

i. Bar size channels are sized according to depth, width of flange, thickness of web, and length.

Example:



D = Depth
1/2" to 3/4" in graduations of 1/16".
3/8" to 1-1/4" in graduations of 1/8".
1-1/4" to 2" in graduations of 1/4".

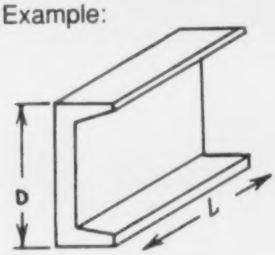
W = Width (of flange) —
1/4", 5/16", 3/8", 7/16", 1/2", 9/16", 3/4", 1".

T = Thickness of web — 1/8", 3/16", 1/4".

Courtesy Lincoln Electric Company

j. Structural channels are sized according to depth of channel and length; common sizes are 3″, 4″, 5″, 6″, 7″, and 8″

Example:

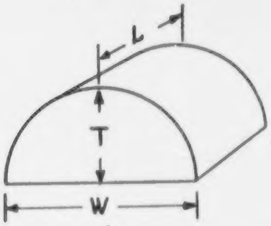


Common sizes are 3", 4", 5", 6", 7", and 8".

Courtesy Lincoln Electric Company

k. Hot-rolled half ovals are sized according to thickness, width, and length; half ovals come in 16′ lengths.

Example:



T = Thickness
3/8" to 1/2" in graduations of 1/16".

W = Width
1/8" to 1-1/4" in graduations of 1/8".
1-1/4" to 2" in graduations of 1/4".
2" to 3" in graduations of 1/2".

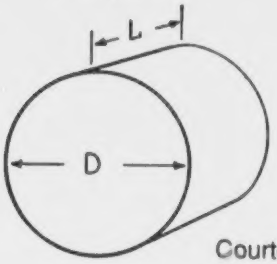
L = Length — 16'.

Courtesy Lincoln Electric Company

Information Sheet

I. Hot and cold-rolled rounds are sized according to diameter and length.

Example:



D = Diameter 3/8" to 2" or larger in graduation increases of 1/16" and 1/8".

L = Length — 16', 18', and 20'.

Courtesy Lincoln Electric Company

Basic Math and Measuring
Unit 5

Assignment Sheet 1—Add, Subtract, Multiply, and Divide Fractions

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Accuracy in adding	______
Accuracy in subtracting	______
Accuracy in multiplying	______
Accuracy in dividing	______

Directions: Review the following procedures for working with fractions, and then complete the problems that follow.

1. To add fractions:

   a. Change all fractions to a common denominator.

   b. Change all mixed numbers to improper fractions.

   c. Add all the numerators.

   d. Write down the total fraction.

   e. Reduce fraction to lowest terms in final form.

   f. If fraction totals to an improper fraction, simplify and reduce to lowest terms.

   Example 1:

   Add: $1/8 + 1/16 + 3/4 + 1/16 = 2/16 + 1/16 + 12/16 + 1/16$

   Change to largest common denominator.

   $2/16 + 1/16 + 12/16 + 1/16 = 16/16 = 1$

   Add numerators, place over common denominator, and reduce to lowest terms.

Assignment Sheet 1

Example 2:

Add: $\frac{3}{8} + \frac{1}{2} + \frac{5}{8} + \frac{3}{4} = \frac{3}{8} + \frac{4}{8} + \frac{5}{8} + \frac{6}{8}$

Change to largest common denominator.

$\frac{3}{8} + \frac{4}{8} + \frac{5}{8} + \frac{6}{8} = \frac{18}{8} = 2\frac{2}{8} = 2\frac{1}{4}$

Add numerators, place over common denominator, change from improper fraction to proper fraction, and reduce to lowest terms.

2. To subtract fractions:

   a. Change all fractions to a common denominator.

   b. Change all mixed numbers to improper fractions.

   c. Subtract the numerators.

   d. Write down the remaining fraction.

   e. Reduce fraction to lowest terms in final form.

   f. If fraction totals to an improper fraction, simplify and reduce to lowest terms

   Example 3:

   Subtract: $\frac{7}{8} - \frac{9}{16} = \frac{14}{16} - \frac{9}{16} = \frac{5}{16}$

   Change to largest common denominator, subtract numerators, complete answer.

   Example 4:

   Subtract: $1\frac{3}{16} - \frac{1}{4} = \frac{19}{16} - \frac{4}{16} = \frac{15}{16}$

   Change mixed number to improper fraction; change fractions to largest common denominator; subtract numerators; complete answer.

   Example 5:

   Subtract: $2\frac{3}{8} - 1\frac{5}{32} = \frac{19}{8} - \frac{37}{32} = \frac{76}{32} - \frac{37}{32} = \frac{39}{32} = 1\frac{7}{32}$

   Change mixed numbers to improper fraction; change fractions to largest common denominator; subtract numerators; change improper fraction to proper fraction; complete answer.

Assignment Sheet 1

3. To multiply fractions:

   a. Multiply numerators.

   b. Multiply denominators

   c. Write down new numerator over new denominator.

   d. Reduce fraction to lowest terms.

   e. If using mixed numbers, change fraction to improper fraction, multiply numerator and denominator, change to a mixed number, reduce fraction remainder to lowest terms.

Example 6:

Multiply: $\frac{5}{8} \times \frac{1}{2} = \frac{5 \times 1}{8 \times 2} = \frac{5}{16}$

Multiply numerator, multiply denominator, complete answer.

Example 7:

$$\frac{3}{4} \times 6 = \frac{3}{4} \times \frac{6}{1} = \frac{3 \times 6}{4 \times 1} = \frac{18}{4} = 4\frac{2}{4} = 4\frac{1}{2}$$

Multiply numerator by the whole number; multiply denominator by one; reduce to proper fraction; reduce to lowest terms; complete answer.

Example 8:

$$23\frac{7}{16} \times 4 = (23 \times 4) + (\frac{7}{16} \times 4) = (92) + (\frac{7 \times 4}{16 \times 1}) = (92) + (\frac{28}{16})$$
$$= (92) + (1\frac{12}{16}) = (92) + (1\frac{3}{4}) = 93\frac{3}{4}$$

Multiply whole number of mixed number by whole number; multiply fractional part of mixed number numerator and denominator by whole number; reduce fractional part of mixed number to proper fraction and lowest terms; add whole numbers of each part; complete answer.

Example 9:

$$1\frac{3}{4} \times 4\frac{3}{8} = \frac{7}{4} \times \frac{35}{8} = \frac{245}{32} = 7\frac{21}{32}$$

Change mixed numbers to improper fractions; multiply numerators and denominators; change improper fraction to proper fraction; complete answer.

Assignment Sheet 1

4. To multiply fractions with the cancellation method:

   a. Extend the fractions on a common line.

   b. Cancel corresponding factors above and below the line.

   c. Multiply canceled fractions.

   Example 10:

$$\frac{1}{2} \times \frac{4}{5} = \frac{5}{\underset{1}{\cancel{2}}} \times \frac{\overset{2}{\cancel{4}}}{5} = \frac{2}{5}$$

   The fraction is reduced before multiplying and this helps avoid the use of larger numbers. Since 2 is a factor of 4, numerators and denominators of the fractions can be reduced by cancellation and make the problem easier to work.

5. To divide fractions:

   a. Express fraction in division form.

   b. Invert numerator and denominator of dividing fraction.

   c. Multiply numerators and denominators.

   d. Reduce fractions to lowest terms.

   e. If answer is an improper fraction, change to proper fraction, and reduce to lowest terms.

   Example 11:

$$\frac{7}{8} \div \frac{1}{2} = \frac{\;\frac{7}{8}\;}{\;\frac{1}{2}\;} = \frac{7}{8} \times \frac{2}{1} = \frac{14}{8} = \frac{7}{4} = 1\frac{3}{4}$$

   Write fraction in division form; invert division fraction; multiply numerators and denominators; change fraction from improper to proper fraction; reduce to lowest terms; complete answer.

Assignment Sheet 1

Example 12:

$$2\frac{1}{4} \div 1\frac{1}{8} \text{ or } \frac{2\frac{1}{4}}{1\frac{1}{8}} = \frac{\frac{9}{4}}{\frac{9}{8}} = \frac{9}{4} \times \frac{8}{9} = \frac{72}{36} = 2$$

Write fraction in either form; change to improper numbers for numerator and denominator; multiply numerators and denominators; change improper fraction to proper fraction; complete answer.

6. Problems

   a. Add the following:

      (1) $\frac{1}{2} + \frac{3}{4}$ = ____________

      (2) $\frac{3}{4} + \frac{5}{8} + \frac{9}{16} + \frac{5}{32}$ = ____________

      (3) $2\frac{1}{2} + 3\frac{3}{4} + 5\frac{5}{8} + \frac{3}{8}$ = ____________

   b. Subtract the following:

      (1) $\frac{7}{8} - \frac{3}{4}$ = ____________

      (2) $1\frac{9}{16} - \frac{3}{4}$ = ____________

      (3) $3\frac{3}{8} - 1\frac{9}{16}$ = ____________

   c. Multiply the following:

      (1) $\frac{5}{8} \times \frac{3}{4}$ = ____________

      (2) $5\frac{5}{16} \times 4$ = ____________

   d. Divide the following:

      (1) $\frac{3}{4} \div \frac{3}{8}$ = ____________

      (2) $2\frac{1}{2} \div 5$ = ____________

Basic Math and Measuring
Unit 5

Assignment Sheet 2—Add, Subtract, Multiply, and Divide Decimal Equivalents

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy in adding	______
Accuracy in subtracting	______
Accuracy in multiplying	______
Accuracy in dividing	______

Directions: Review the following procedures for working with decimal equivalents, and then complete the problems that follow.

1. To work decimal equivalents:
   a. Write first decimal number.
   b. Write second decimal number under first decimal number.

      Note: Decimal points must be in line.
   c. If there are more than two decimal numbers, continue to list each in column order keeping the decimal points in line.
   d. Complete answer.
   e. Place decimal point in proper position for final answer.
2. To add decimals:

   Example 1:

$$\begin{array}{r} 0.9375 \\ \underline{+0.5250} \\ 1.4625 \end{array}$$

Assignment Sheet 2

3. To subtract decimals:

   Example 2:

$$\begin{array}{r} 0.3857 \\ \underline{-0.0125} \\ 0.3732 \end{array}$$

4. To multiply decimals:

   Example 3:

$$\begin{array}{r} 0.2343 \\ \underline{\times 5} \\ 1.1715 \end{array}$$

   Note: Count over four decimals on completed answer for correct decimal positioning.

5. To divide decimals:

   Example 4:

$$2.3865 \div 3 = \begin{array}{r} 0.7955 \\ 3\overline{)2.3865} \\ \underline{2\,1} \\ 28 \\ \underline{27} \\ 16 \\ \underline{15} \\ 15 \\ \underline{15} \end{array}$$

   Note: Indicate whole unit as zero or whole number before the decimal.

6. Problems

   a. Add the following decimal equivalents:

      (1) 2.125 + 2.375 + 4.0625 + 9.0008 + 0.12 = ____________

      (2) 0.046 + 0.00002 + 0.653 + 8.1673 = ____________

      (3) 0.5000 + 0.015 + 0.171 + 8.7003 + 16.37 = ____________

Assignment Sheet 2

b. Subtract the following decimal equivalents:

(1) 8.763 - 0.041 = ____________

(2) 126.373 - 126.219 = ____________

(3) 9 - 0.125 = ____________

Note: 9 = 9.000.

c. Multiply the following decimal equivalents:

(1) 0.9321 × 1.76 = ____________

(2) 9.429 × 8.670 = ____________

d. Divide the following decimal equivalents:

(1) 0.0672 ÷ 28 = ____________

(2) 73.16 ÷ 24 = ____________

Basic Math and Measuring
Unit 5

Assignment Sheet 3—Convert Fractions to Decimal Form, Change Fractions to a Common Denominator, and Reduce Fractions to Lowest Terms

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy with conversion	______
Accuracy with common denominator	______
Accuracy with reduction to lowest terms	______

Directions: Review the following procedures for converting fractions to decimal form, changing fractions to a common denominator, and reducing fractions to lowest terms, and then complete the problems that follow.

1. To convert fractions to decimal form:

   Example 1:

$$\begin{array}{l} \qquad\quad\ 0.500 \\ \tfrac{1}{2} = 2\overline{)1.000} = 0.500 \\ \qquad\quad\ \underline{1.000} \end{array}$$

   Example 2:

$$\begin{array}{l} \qquad\quad\ 0.500 \\ \tfrac{3}{4} = 4\overline{)3.000} = 0.750 \\ \qquad\quad\ \underline{28} \\ \qquad\quad\ 20 \\ \qquad\quad\ \underline{20} \\ \qquad\quad\ \ \ 0 \end{array}$$

   Divide the denominator into the numerator; place the decimal in the correct position; use quotient as the answer.

2. To change fractions to a common denominator:

   Example 3:

$$\frac{1}{2} + \frac{1}{4} + \frac{5}{8} = \frac{1 \times 4}{2 \times 4} + \frac{1 \times 2}{4 \times 2} + \frac{5}{8} = \frac{4}{8} + \frac{2}{8} + \frac{5}{8} = \frac{11}{8} = 1\frac{3}{8}$$

Assignment Sheet 3

Example 4:

$$\frac{1}{16} + \frac{3}{32} + \frac{5}{64} + \frac{3}{4} = \frac{1 \times 4}{16 \times 4} + \frac{3 \times 2}{32 \times 2} + \frac{5}{64} + \frac{3 \times 16}{4 \times 16} = \frac{4}{64} + \frac{6}{64} + \frac{5}{64} + \frac{48}{64} = \frac{63}{64}$$

Using the largest denominator, place all fractions in the same base by multiplying both numerator and denominator by same base power; add all numerators; complete answer.

Note: Above examples did not have to be reduced to lowest terms, but Example 3 had to be changed from an improper to a proper fraction.

3. To reduce a fraction to lowest terms:

Example 5:

$$\frac{6}{8} = \frac{6 \div 2 = 3}{8 \div 2 = 4} = \frac{3}{4}$$

Example 6:

$$\frac{24}{32} = \frac{24 \div 8 = 3}{32 \div 8 = 4} = \frac{3}{4}$$

A fraction is in its lowest terms when numerator and denominator are divided by the greatest factor common to both.

Note: Fractions may be reduced by powers of 2 or by inspection for the greatest common divisor.

4. Problems

a. Convert the following fractions to decimal form. Show all work.

(1) ½ = ______________

(2) ⅝ = ______________

(3) ¼ = ______________

(4) ⅛ = ______________

(5) 5⁄16 = ______________

(6) 9⁄16 = ______________

(7) ¾ = ______________

Assignment Sheet 3

(8) $\frac{7}{8}$ = ______________

(9) $\frac{3}{8}$ = ______________

(10) $\frac{11}{16}$ = ______________

b. Change the following fractions to a common denominator and solve.

(1) $\frac{1}{8} + \frac{1}{4}$ = ______________

(2) $\frac{1}{16} + \frac{5}{32} + \frac{3}{8}$ = ______________

(3) $\frac{7}{8} + \frac{9}{16} + 1\frac{1}{8} + \frac{5}{32}$ = ______________

(4) $\frac{15}{64} - \frac{1}{8}$ = ______________

(5) $\frac{7}{64} + \frac{11}{16} + \frac{9}{64} + \frac{1}{8} + \frac{7}{16} + \frac{1}{4} + \frac{3}{32}$ = ______________

c. Reduce the following fractions to lowest terms.

(1) $\frac{12}{16}$ = ______________

(2) $\frac{16}{24}$ = ______________

(3) $\frac{48}{64}$ = ______________

(4) $\frac{25}{75}$ = ______________

(5) $\frac{22}{64}$ = ______________

(6) $\frac{72}{128}$ = ______________

(7) $\frac{63}{56}$ = ______________

(8) $\frac{500}{800}$ = ______________

(9) $\frac{57}{48}$ = ______________

(10) $\frac{150}{200}$ = ______________

Note: Change improper fractions to proper form; then reduce to lowest terms.

Basic Math and Measuring
Unit 5

Assignment Sheet 4—Write Fractions as Decimals and Percents

Name ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Accuracy with fractions as decimals	______
Accuracy with fractions as percents	______

Directions: Review the following procedures for writing fractions as decimals and percents, and then complete the problems that follow.

1. Expressing fractions as decimals; divide the numerator by the denominator.

   Example: $\frac{5}{8}$

$$\begin{array}{r} .625 \\ 8\overline{)5.000} \\ \underline{4\,8} \\ 20 \\ \underline{16} \\ 40 \\ \underline{40} \end{array}$$

2. Expressing fractions as percents:
   a. Express the fraction in decimal form.
   b. Move the decimal point two places to the right.
   c. Place the % symbol after the number.

   Example: $\frac{7}{33}$

$$\begin{array}{r} .2121 = 21.21\% \\ 33\overline{)7.00} \\ \underline{6\,6} \\ 40 \\ \underline{33} \\ 70 \\ \underline{66} \\ 40 \\ \underline{33} \\ 7 \end{array}$$

Note: Percent means that some number is being compared to 100.

Assignment Sheet 4

d. Multiply the numerator and denominator by that number which will change the denominator to 100.

e. Drop the denominator.

f. Add the % symbol.

Example: $\frac{3}{4} = \frac{3}{4} \times \frac{25}{25} = \frac{75}{100} = 75\%$

3. Problems

a. Express each fraction as a decimal.

(1) 1/8 ______________

(2) 1/4 ______________

(3) 1/2 ______________

(4) 3/4 ______________

(5) 5/8 _________ _____

(6) 7/20 ______________

(7) 7/16 ______________

(8) 1/9 ______________

(9) 4/9 ______________

(10) 4/5 ______________

b. Express each fraction as a percent.

(1) 1/4 ______________

(2) 2/9 ______________

(3) 7/10 ______________

(4) 3/4 ______________

(5) 2/2 ______________

(6) 9/11 ______________

Assignment Sheet 4

(7) 1/3 ______________

(8) 4/9 ______________

(9) 2/6 ______________

(10) 5/8 ______________

Basic Math and Measuring
Unit 5

Assignment Sheet 5—Write Percents as Fractions and Decimals

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy with percents as fractions	______
Accuracy with percents as decimals	______

Directions: Review the following procedures for writing percents as fractions and decimals, and then complete the problems that follow.

1. Expressing percents as fractions:
   a. Drop the percent symbol.
   b. Place the number over 100.

   Note: Reduce to simplest form.

   Example: 38% $= \frac{38}{100} = \frac{19}{50}$

2. Expressing percents as decimals:
   a. Drop the percent symbol.
   b. Move the decimal point two places to the left.

   Examples: 75% = .75 and 33⅓% = .333

3. Problems
   a. Express each percent as a fraction.
      (1) 50% ____________
      (2) 25% ____________
      (3) 33⅓% ____________
      (4) 36% ____________

Assignment Sheet 5

(5) 28% ____________

(6) $14\frac{2}{7}$% ____________

(7) 21% ____________

(8) 45% ____________

(9) $66\frac{2}{3}$% ____________

(10) 70% ____________

b. Express each percent as a decimal.

(1) 47% ____________

(2) 15% ____________

(3) 33.3% ____________

(4) 62% ____________

(5) 75% ____________

(6) 3% ____________

(7) 16.8% ____________

(8) 9% ____________

(9) 10% ____________

(10) 50% ____________

Basic Math and Measuring
Unit 5

Assignment Sheet 6—Write Decimals as Fractions and Percents

Name ______________________ Overall Rating __________

Evaluation criteria	Rating
Accuracy with decimals as fractions	______
Accuracy with decimals as percents	______

Directions: Review the following procedures for writing decimals as fractions and percents, and then complete the problems that follow.

1. Expressing decimals as fractions:

   a. If there is one decimal place, drop the decimal point and place the number over 10.

      Example: $.4 = \frac{4}{10} = \frac{2}{5}$

   b. If there are two decimal places, drop the decimal point and place the number over 100.

      Example: $.75 = \frac{75}{100} = \frac{3}{4}$

   c. If there are three decimal places, drop the decimal point and place the number over 1000.

      Example: $.375 = \frac{375}{1000} = \frac{3}{8}$

      Note: Do not forget to reduce to simplest form.

2. Expressing decimals as percents:

   a. Move the decimal point two places to the right.

   b. Place the percent symbol after the number.

      Examples: 4 = 400%
      .37 = 37%

Assignment Sheet 6

3. Problems

a. Express each decimal as a fraction.

(1) .5 ____________

(2) .8 ____________

(3) .7 ____________

(4) .25 ____________

(5) .68 ____________

(6) .55 ____________

(7) .94 ____________

(8) .375 ____________

(9) .875 ____________

(10) .212 ____________

b. Express each decimal as a percent.

(1) .12 ____________

(2) .19 ____________

(3) .7 ____________

(4) .29 ____________

(5) .37 ____________

(6) .42 ____________

(7) .5 ____________

(8) .523 ____________

(9) .746 ____________

(10) 3.75 ____________

Basic Math and Measuring
Unit 5

Assignment Sheet 7—Make Conversions with a Decimal Equivalent Chart

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy with decimal equivalents	______
Accuracy with fractional equivalents	______

Directions: Review the following procedures for writing fractions as decimal equivalents and writing decimal equivalents as fractions, and then complete the problems that follow.

1. Observe the order of fraction listings from small to large sizes on the decimal equivalent chart.

   Note: If using a chart other than the one provided, ask the instructor to explain the chart.

2. Observe the order of decimal listings from small to large sizes.

3. Locate a fractional size and then locate the decimal equivalent directly to the right (usually connected by a bar or line).

4. Using reverse order in item C, locate the decimal equivalent and read the fractional size directly to the left (usually connected by a bar or line).

5. Problems

   Note: Be sure to reference the Decimal Equivalent Chart that accompanies this job sheet.

   a. Locate and list the decimal equivalent for the fractional sizes listed below:

      (1) $\frac{1}{16}$ = __________

      (2) $\frac{7}{8}$ = __________

      (3) $\frac{1}{4}$ = __________

      (4) $\frac{1}{2}$ = __________

      (5) $\frac{9}{16}$ = __________

Assignment Sheet 7

b. Locate and list the fractional size for the decimal equivalents listed below:

(1) 0.4375 = ____________

(2) 0.3125 = ____________

(3) 0.375 = ____________

(4) 0.125 = ____________

(5) .6875 = ____________

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.25	3/4	.75
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
29/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.5	1	1.

Basic Math and Measuring
Unit 5

Assignment Sheet 8—Make Conversions with an Inches-to-Decimal Conversion Chart

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy with feet and inches to decimals	______
Accuracy with decimals to feet and inches	______

Directions: Review the following procedures for converting feet and inches to decimals and converting decimals to feet and inches. Then complete the problems that follow.

1. Converting feet and inches to decimals:

   a. Determine total number of full feet and multiply by 1.000.

   Example: To convert 5′ 7½″ to decimals, first multiply 5 × 1.000 = 5.000

   b. Determine total number of full inches and divide by 12, and add to total number of full feet.

   Example: In converting 5′ 7½″ to decimals, first multiply the 5′ by 1.000 = 5.000, then divide 7 by 12,

   $$\begin{array}{r} .5833 \\ 12\overline{)7.000} \\ 6\,00 \\ 1\,00 \\ 96 \\ 40 \\ 36 \\ 40 \end{array}$$

   then add .5833 to 5.000 = 5.5833

   Note: Be sure to reference the Inches-to-Decimal Chart that accompanies this job sheet.

Assignment Sheet 8

c. Determine fractions of inches i the measurement, divide the numerator (top number) by the denominator (bottom number), then divide that total by 12, and add this figure to the full feet and full inches.

Example: The fractional ½″ converts to a decimal by dividing 1 by 2,

. . .5833
2)1.000
. 1 0
. . 000

and then dividing .5000 by 12,

.0417 (round off to 7)
2)1.000
4 8
20
12
80
84

and add the .0417 to 5.5833
.0417
5.6250

which makes 5.6250 the decimal conversion of 5′ 7½″

2. Converting decimals to feet and inches:

a. Convert the decimal figure to the left of the decimal point into full feet.

Example: In the decimal measurement 5.6250′, the 5 to the left of the decimal = 5′

b. Convert the decimal figure to the right of the decimal point into full inches by multiplying by 12.

. .6250
×. 12
1.2500
6.250
7.5000

c. Convert the decimal figure to the left of the decimal point into full inches.

Example: In the decimal measurement 7.500, the 7 to the left of the decimal = 7″

Assignment Sheet 8

d. Convert the remaining decimal figure to fractions of an inch by multiplying by 1.000 and reducing it to its lowest terms.

Example: When the decimal measurement .5000 is multiplied by 1.000, the result is .5, so to convert this, drop the decimal point and place the figure over 10 to get 5/10, then reduce this figure to its lowest terms to get ½″ so that the decimal measurement of 5.6250 = 5′ 7½″

Note: If the figure has two numbers to the right of the decimal point, place it over 100 instead of 10, so the figure .56 would be 56/100.

3. Problems

Note: Be sure to follow rules for rounding off figures.

a. Convert the following feet and inches to decimals

(1) 9′ 6¾″ = ____________

(2) 3′ 4⅝″ = ____________

(3) 14′ 2¼″ = ____________

(4) 1′ 6″ = ____________

b. Convert the following decimals to feet and inches

(1) 2.5000′ = ____________

(2) 8.6333′ = ____________

(3) 11.7425′ = ____________

(4) 17.1125′ = ____________

Assignment Sheet 8

Inches-to-Decimal Conversion Chart

1/16″	.0052
3/32″	.0078
1/8″	.0104
5/32″	.0130
3/16″	.0156
7/32″	.0182
1/4″	.0208
9/32″	.0234
5/16″	.0260
3/8″	.0313
7/16″	.0364
1/2″	.0417
9/16″	.0468
5/8″	.0521
11/16″	.0572
3/4″	.0625
13/16″	.0677
7/8″	.0726
15/16″	.0781

1″	.0833
2″	.1667
3″	.2500
4″	.3333
5″	.4167
6″	.5000
7	.5833
8″	.6667
9″	.7500
10″	.8333
11″	.9167
12″	1.0000

Basic Math and Measuring
Unit 5

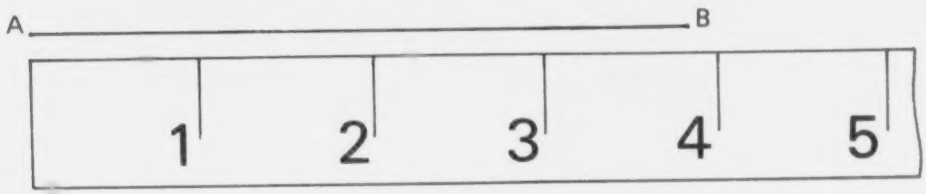
Assignment Sheet 9—Measure Distances with 1″, ½″, and ¼″ Graduations

Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Accuracy with 1″ graduations	______
Accuracy with ½″ graduations	______
Accuracy with ¼″ graduations	______

Directions: Study the rules in the illustrations and answer the questions about the graduations on each set of rules.

1. a. Point A, on line segment AB below, is at the end of the rule. Point B is nearest what number? __________



b. Is AB exactly 4 inches long? __________

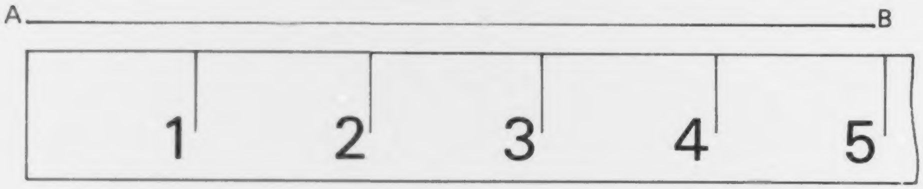
c. Is AB exactly 3 inches long? __________

d. AB above is approximately __________ inches in length.

e. Would a measurement less than a full inch be exact on this rule? __________

Assignment Sheet 9

2. a. Is AB below exactly 5 inches long? __________



b. Is the measure of AB closer to 4 inches or 5 inches? __________

c. Can this rule normally be used to measure with complete accuracy? __________

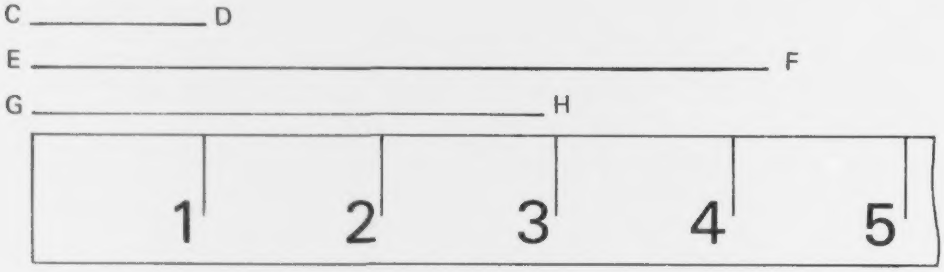
d. Always measure to the __________ __________ marked on the ruler.

3. On the rule below, give the measure of each line segment to the nearest mark. Label your answers with the correct unit of measure.

a. CD = __________

b. EF = __________

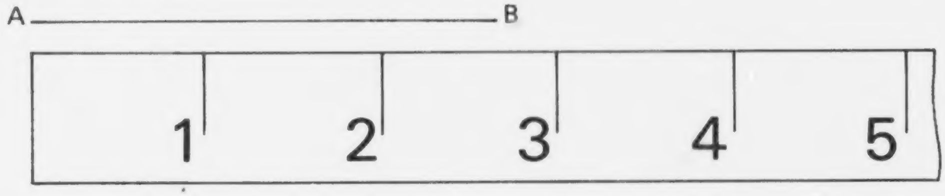
c. GH = __________



d. Are the measurements above exact or approximate? __________

Assignment Sheet 9

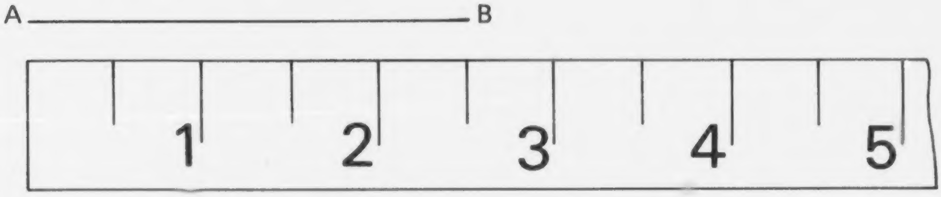
4.



a. Is 3 inches an accurate measure for AB above? ____________

b. Could we get a more accurate measure of AB if we divided the inches into smaller units? ____________

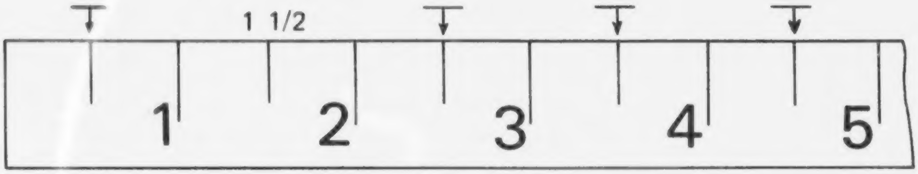
5. a. Into how many parts has each inch been divided on the rule below? ____________



b. Is B located nearer 2, 2½, or 3 inches? ____________

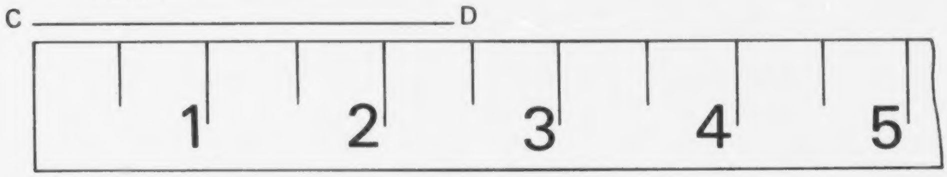
Note: Remember, always read to the nearest mark on a rule.

6. Write in the missing numbers.



7. a. Is point D below nearer 2 or 2½? ____________

b. Therefore, using this rule, the measure of CD is approximately ____________ inches.



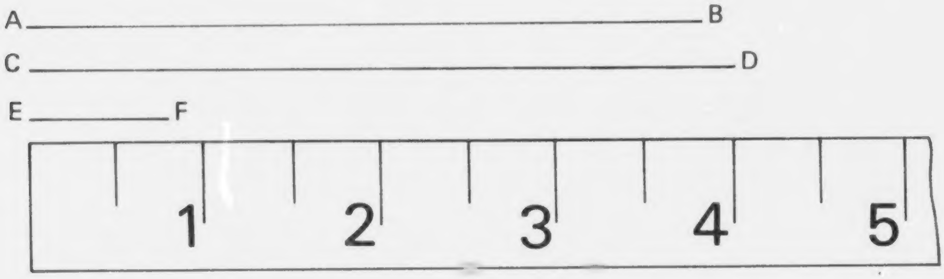
Assignment Sheet 9

8. To measure a line segment, line up one of its end points with the end of the rule. Give the approximate measure of each segment shown below.

   a. AB = __________

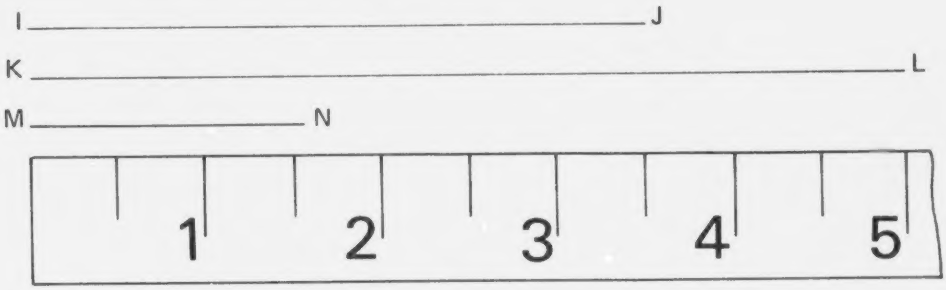
   b. CD = __________

   c. EF = __________



   d. Although the measures given above are correct, are they exact? __________

9. Give the measure of each line segment below:



   a. IJ = __________

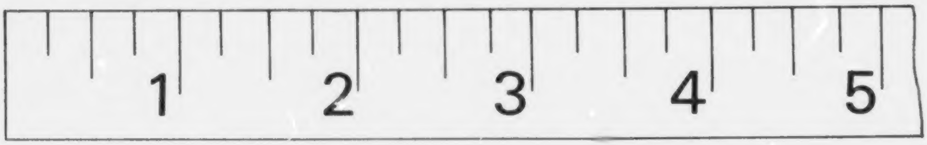
   b. KL = __________

   c. MN = __________

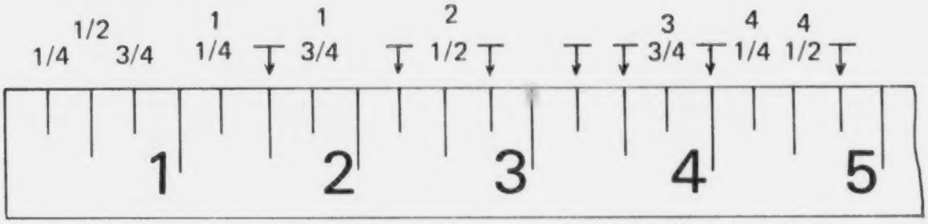
10. a. To get a still more accurate measurement, divide ½-inches into two smaller units. Since ½ ÷ 2 = ¼, the new marks would be __________ of an inch apart.

Assignment Sheet 9

b. Each inch on the rule below is divided into how many parts? ____________



11. Fill in the missing numbers.


1/4
1/2
3/4
1 1/4
1 3/4
2 1/2
3 3/4
4 1/4
4 1/2
1
2
3
4
5

Basic Math and Measuring
Unit 5

Assignment Sheet 10—Measure Distances with ¼″, and ⅛″ Graduations

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy with ¼″ graduations	______
Accuracy with ⅛″ graduations	______

Directions: In the following problems, measurements should be written as whole numbers, if possible. If not possible, write measurements as a whole number and a fraction. Write all fractions in their lowest terms. For example, $\frac{4}{8}$ or $\frac{8}{16}$ should be written as $\frac{1}{2}$.

1. Circle the preferred measurement in each of the pairs below.

   a. $5\frac{6}{8}$ or $5\frac{3}{4}$

   b. $\frac{1}{2}$ or $\frac{6}{12}$

   c. $1\frac{8}{16}$ or $1\frac{1}{2}$

   d. $7\frac{4}{16}$ or $7\frac{1}{4}$

   e. $3\frac{2}{8}$ or $3\frac{1}{4}$

2. Write the following measures in simplest form.

   Example: $2\frac{10}{16} = 2\frac{5}{8}$

   a. $2\frac{8}{16}$

   b. $1\frac{6}{8}$

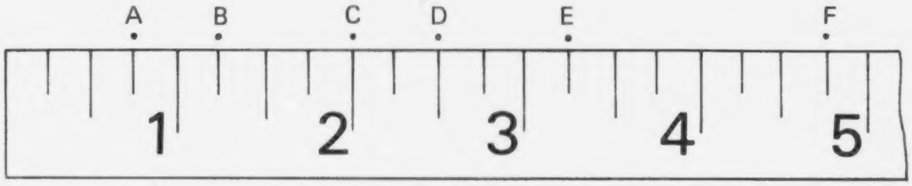
   c. $2\frac{8}{8}$

   d. $7\frac{14}{16}$

   e. $3\frac{3}{16}$

Assignment Sheet 10

3. Give the preferred measurement for each of the points shown below.


A
B
C
D
E
F
1
2
3
4
5

a. Point A: ____________

b. Point B: ____________

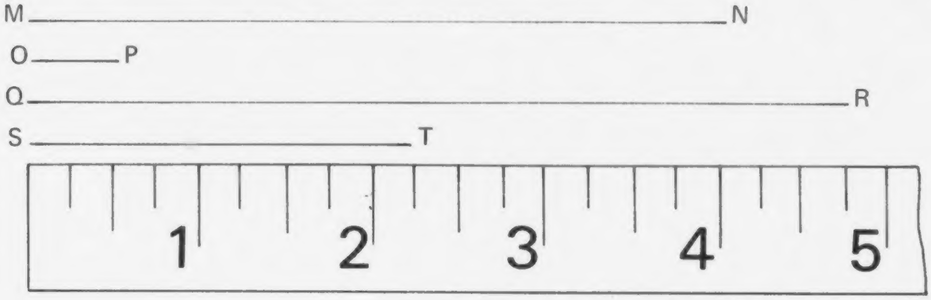
c. Point C: ____________

d. Point D: ____________

e. Point E: ____________

f. Point F: ____________

4. Give the measures of these line segments.


M
N
O
P
Q
R
S
T
1
2
3
4
5

a. MN = ____________

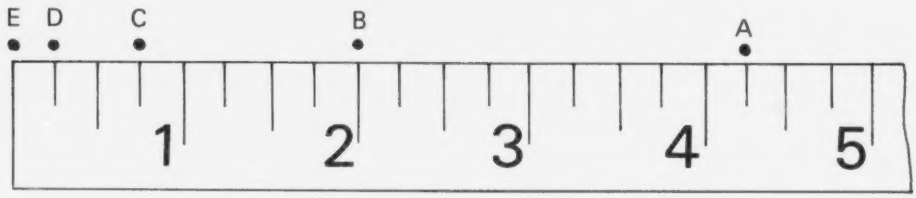
b. OP = ____________

c. QR = ____________

d. ST = ____________

Assignment Sheet 10

5. Which point on the rule below represents zero? ____________



6.

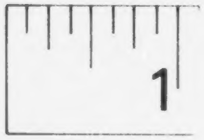


Figure A

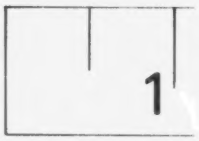


Figure B

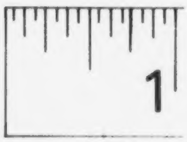


Figure C

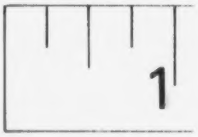


Figure D

a. In Figure A, the inch has been divided into ____________ parts.

b. In Figure B, the inch has been divided into ____________ parts.

c. In Figure C, the inch has been divided into ____________ parts.

d. In Figure D, the inch has been divided into ____________ parts.

e. When the inch is divided into two equal parts, each part is called a ____________.

f. When the inch is divided into four equal parts, each part is called a ____________.

g. There are ____________ halves in 1 inch.

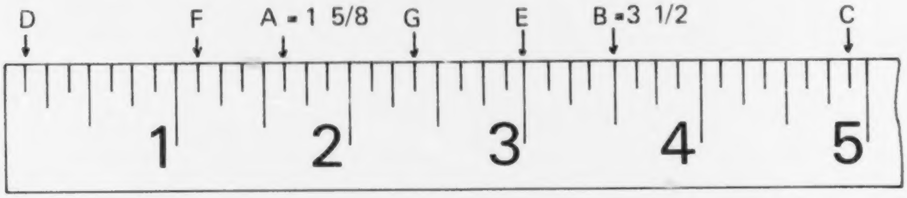
h. There are ____________ fourths in 1 inch.

Assignment Sheet 10

7. a. Each inch on the rule shown below is divided into ____________ equal parts.

   b. These equal parts are called ____________ of an inch.

   c. How many eights are in one inch? ____________



8. Give the reading of these points on the preceding rule.

   a. Point C: ____________

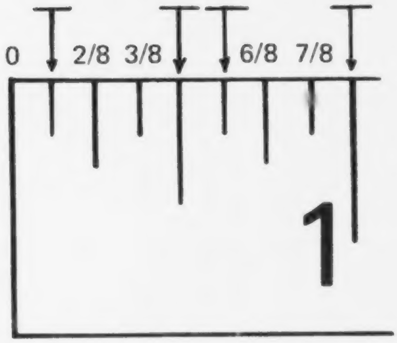
   b. Point D: ____________

   c. Point E: ____________

   d. Point F: ____________

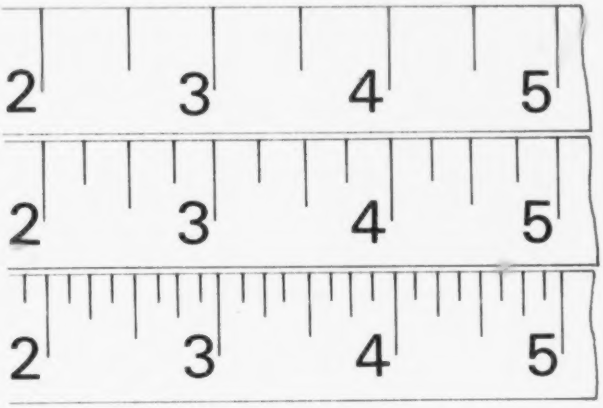
   e. Point G: ____________

9. What fractions are missing? (Write all answers as eighths.)



Assignment Sheet 10

10. In the figure below are three rules. One is divided into halves, one into fourths, and the other into eighths. Use these to complete the problems that follow.



a. $3\frac{1}{2} = 3\frac{\_}{4} = 3\frac{\_}{8}$

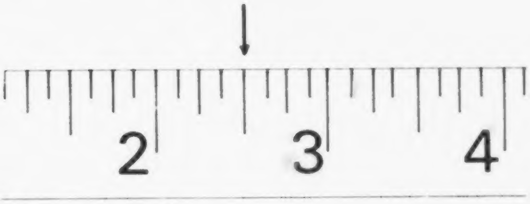
b. $2\frac{1}{4} = 2\frac{\_}{8}$

c. $3\frac{3}{4} = 3\frac{\_}{8}$

11. The arrow in the figure below points to a mark than can be read as 2½. Give two other names for this point.

a. ____________________

b. ____________________



Basic Math and Measuring
Unit 5

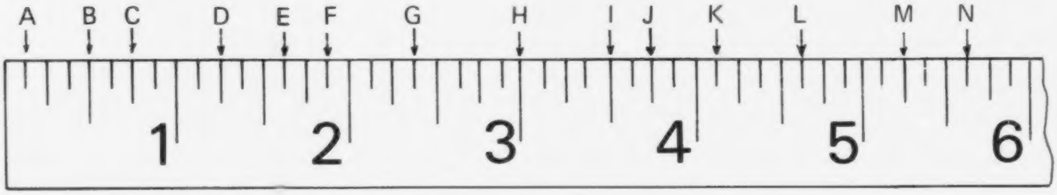
Assignment Sheet 11—Measure Distances with ⅛″ Graduations

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy with point identification	______
Accuracy with distance measurements	______

Directions: In problem 1, an indicated point means 2¼″ or whatever point is indicated. Problem 2 requires indicating distances from one point to another. Use the rule in the illustration.

1. Use the drawing below and give the reading of the indicated points. Be sure answers are in lowest terms.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

k. ______________________

l. ______________________

m. ______________________

n. ______________________

Assignment Sheet 11

2. Use the previous drawing to find the distance between the following letters. Give answers in lowest terms.

a. F to H ______________________

b. D to E ______________________

c. A to C ______________________

d. I to J ______________________

e. B to H ______________________

f. B to I ______________________

g. H to K ______________________

h. B to C ______________________

i. K to L ______________________

j. H to M ______________________

Basic Math and Measuring
Unit 5

Assignment Sheet 12—Measure Distances with ⅟₁₆″ Graduations

Name ______________________ Overall Rating ________

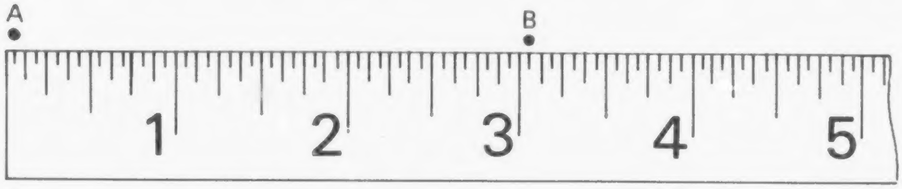
Evaluation criteria	Rating
Accuracy with distance measurements	______
Identification of missing fractions	______
Evaluation of stated measurements	______

Directions: Study the rule in the illustration and carefully read the questions. Answer all questions in the form indicated.

1. a. Each inch on the rule below is divided into ____________ equal parts.

   b. Each small unit represents what fraction of an inch? ____________

   c. How many sixteenths in an inch? ____________; a half inch? ____________



   d. How far is Point A from the zero end of the rule? ____________

   e. How far is Point B from the zero end of the rule? ____________

2. a. How many ½-inch units are in an inch? ____________

   b. How many ⅛-inch units are in an inch? ____________

   c. How many 1-inch units are in an inch? ____________

   d. How many ¼-inch units are in an inch? ____________

   e. How many ⅟₁₆-inch units are in an inch? ____________

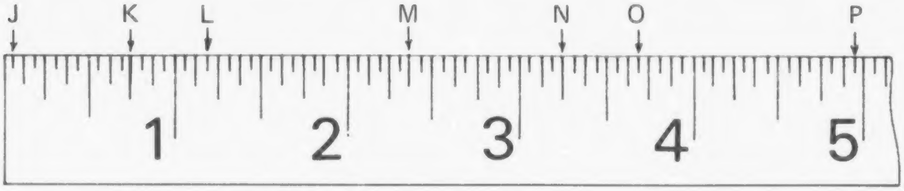
Assignment Sheet 12

3. a. Each inch on the rule shown below is divided into ____________ equal parts.

   b. Each part is called a ____________ of an inch.

   c. There are how many sixteenths in one inch? ____________

   d. There are how many sixteenths in one-half inch? ____________


J
K
L
M
N
O
P
1
2
3
4
5

4. Use the previous rule to answer these questions. Are these measures correct? Answer yes or no for each one.

   a. J: $\frac{1}{16}$ ____________

   b. K: $\frac{1}{2}$ ____________

   c. L: $1\frac{3}{16}$ ____________

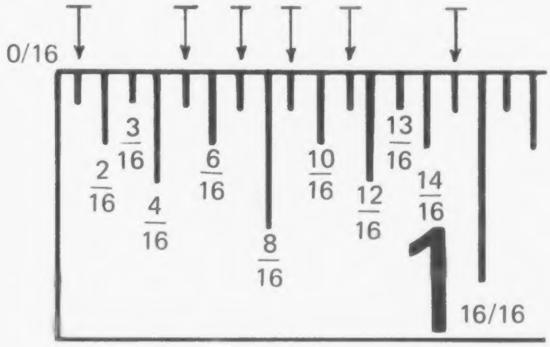
   d. M: $2\frac{3}{8}$ ____________

   e. N: $3\frac{1}{8}$ ____________

   f. O: $3\frac{11}{16}$ ____________

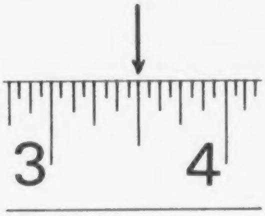
   g. P: $4\frac{7}{8}$ ____________

5. a. Name the missing fractions below:

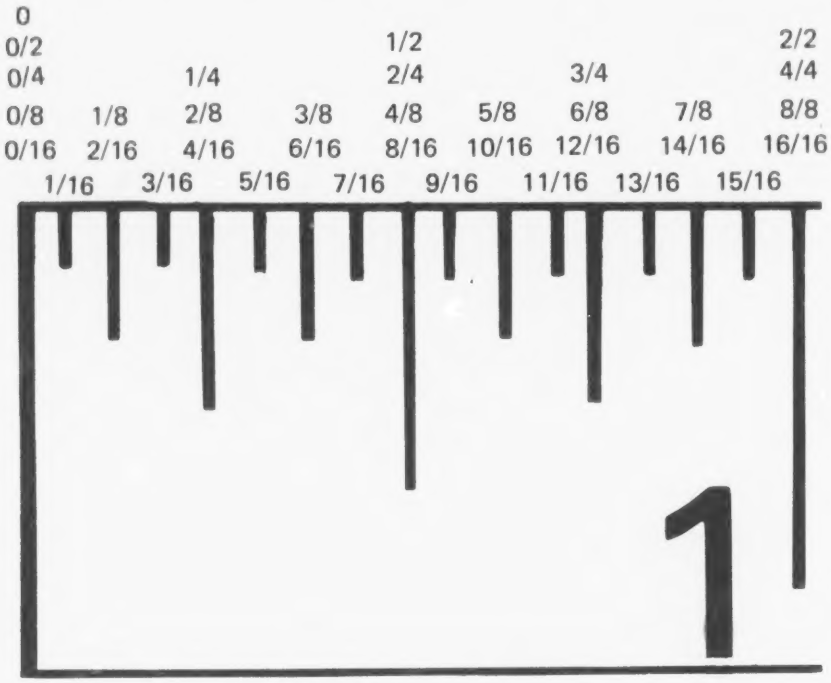

0/16
2/16
3/16
4/16
6/16
8/16
10/16
12/16
13/16
14/16
1
16/16

Assignment Sheet 12

b. The point marked on the rule below could be named $3\frac{8}{16}$. It could also be named $3\frac{\_}{8}$, $\frac{\_}{4}$, or $3\frac{\_}{2}$



6. The rule below shows that $\frac{1}{4}$, $\frac{2}{8}$, and $\frac{4}{16}$ are all names for the same point on the rule.


0
0/2
0/4
0/8
0/16
1/16
1/8
2/16
3/16
1/4
2/8
4/16
5/16
3/8
6/16
7/16
1/2
2/4
4/8
8/16
9/16
5/8
10/16
11/16
3/4
6/8
12/16
13/16
7/8
14/16
15/16
2/2
4/4
8/8
16/16
1

a. Another name for $\frac{2}{16}$ is ____________.

b. Other names for $\frac{12}{16}$ are ____________.

c. Other names for 1 inch are ____________.

Assignment Sheet 12

d. Another name for 6/16 is ____________.

e. The simplest name for 10/16 is ____________.

f. 12/16 reduced to lowest terms is ____________.

g. At the left end of the rule is the ____________ point.

h. Are the fractions 1/16, 3/16, 5/16, 7/16, 9/16, 11/16, 13/16, and 15/16 in simplest form? ____________

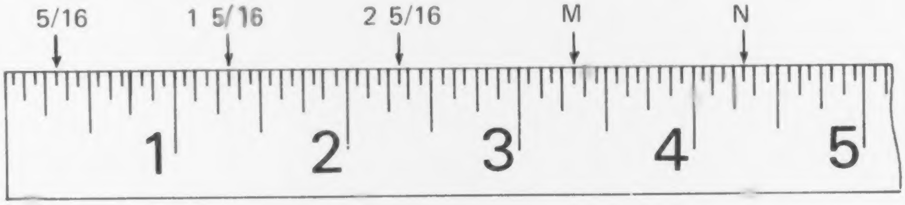
7. a. The following rule is divided into (16ths, 32nds). Circle the correct answer.

b. The first five units on this rule represent 5/16 of an inch. Five small units to the right of the 1-inch mark is the mark representing 1 /16 inches.

c. Five small units to the right of the 2-inch mark is the mark representing 2 /16 inches.

d. Give the reading of point M. ____________

e. Give the reading of point N. ____________



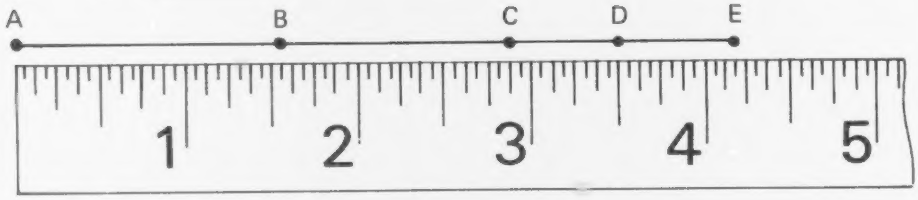
8. What are the measures of the following segments?

a. AB = ____________

b. AC = ____________

c. AD = ____________

d. AE = ____________



Assignment Sheet 12

9. What is the length of JK in:

Note: Read the rule to the nearest mark.

a. Figure A ______________

b. Figure B ______________

c. Figure C ______________

d. Figure D ______________

e. Figure E ______________

f. Which figure shows the rule that would give the most accurate measure of JK?

____

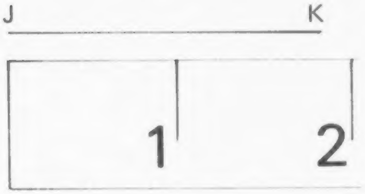


Figure A

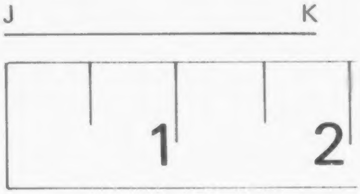


Figure B

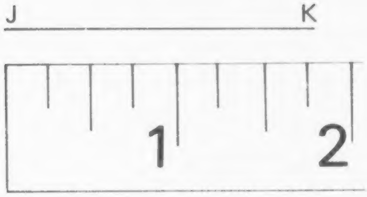


Figure C

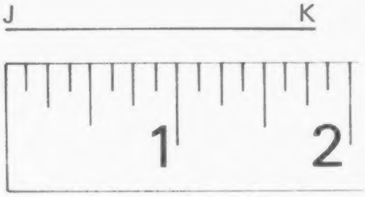
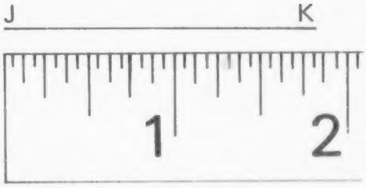


Figure D

Figure E



Basic Math and Measuring
Unit 5

Assignment Sheet 13—Make Conversions with an English-Metric Conversion Chart

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Accuracy of length conversions	_____
Accuracy of weight conversions	_____

Directions: Use the English-Metric conversion chart that accompanies this assignment sheet to identify English measurement and the metric measurement you want to convert it to. Multiply by the conversion factor to arrive at your answer to the following problems; it may pay to use decimal equivalents in certain cases.

1. The wall thickness of a piece of steel tubing is 1/64′. How many centimeters thick is the steel tubing? __________
2. A piece of steel round bar is 16′ long. How many meters long is the bar? __________
3. A bag of flux weighs 3 kilograms. How many pounds does the flux weigh? __________
4. A sheet of mild steel weighs 18 kilograms. how many pounds does the steel sheet weigh? __________

Assignment Sheet 13

ENGLISH-METRIC CONVERSION CHART

	When Your Know	You Can Convert To	When You Multiply By the Conversion Factor
LENGTH	Inches	Millimeters (mm)	25.4
	Millimeters	Inches	0.04
	Inches	Centimeters (cm)	2.54
	Centimeters	Inches	0.4
	Inches	Meters (m)	0.0254
	Meters	Inches	39.37
	Feet	Centimeters	30.5
	Centimeters	Feet	4.8
	Feet	Meters	0.305
	Meters	Feet	3.28
	Miles	Kilometers (km)	1.61
	Kilometer	Miles	0.62
WEIGHT (MASS)	Ounces	Grams	28.4
	Grams	Ounces	0.035
	Pounds	Kilograms	0.45
	Kilograms	Pounds	2.2

Basic Math and Measuring
Unit 5

Job Sheet 1—Adjust a Bevel Square to a 45° Angle using a Framing Square, a Combination Square, and a Protractor

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
Angle adjustment with framing square	______
Angle adjustment with combination square	______
Angle adjustment with protractor	______

A. Tools and materials

Bevel square
Framing square
Combination square
Protractor
Safety glasses

B. Procedure

Note: The illustrations and procedures in this job sheet are adapted from materials originally published by the Research and Curriculum Unit for Vocational-Technical Education, College of Education, Mississippi State University, Mississippi State, MS, and are reprinted with permission.

☐ 1. Put on safety glasses.

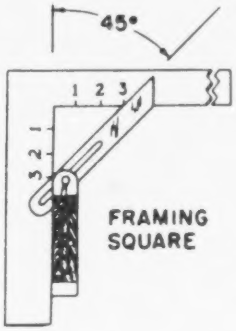
☐ 2. Place the framing square on a clean work area.

☐ 3. Loosen the locking screw on the bevel square so that the blade moves with a slight friction.

☐ 4. Place the handle along the inside of the blade of the framing square so that it is straight against the framing square.

Job Sheet 1

☐ 5. Adjust the blade on the bevel square so that it is at a graduation on the tongue of the framing square equal to the graduation scale at the handle of the bevel square.



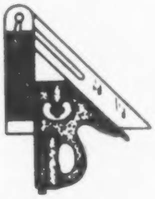
☐ 6. Hold the bevel square with one hand and tighten the locking screw with the other hand.

☐ 7. Have your instructor check for an exact 45° angle on your bevel square.

☐ 8. Loosen the thumb screw on a combination square and slide the handle off the scale.

☐ 9. Loosen the locking screw on the bevel square so that the blade moves with a slight friction.

☐ 10. Place the handle of the combination square on a clean work area, hold it in place with one hand, adjust the blade on the bevel square so that it fits firmly over the 45° angle on the combination square, then tighten the bevel square locking screw.



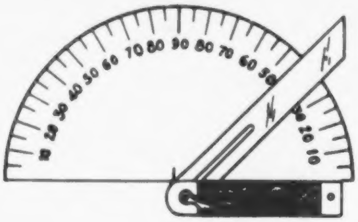
☐ 11. Have your instructor check for an exact 45°angle on your bevel square.

☐ 12. Place a protractor on a clean work area.

☐ 13. Loosen the locking screw on the bevel square so that the blade moves with a slight friction.

Job Sheet 1

☐ 14. Place the handle of the bevel square at the bottom edge of the protractor, hold it with one hand so that it is straight, exactly over the 45° angle on the protractor, then tighten the locking screw.



☐ 15. Have your instructor check for an exact 45° angle on your bevel square.

☐ 16. Return tools and materials to proper storage area.

Evaluator's comments: ____

____

____

Basic Math and Measuring
Unit 5

Job Sheet 2—Form 90° and 45° Angles with a Combination Square and Draw Parallel Lines on Metal Stock

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation criteria	**Rating**
90° angle formation	______
45° angle formation	______
Creation of parallel lines	______

A. Tools and materials

Combination square
Framing square
Sharpened soapstone
Flat metal stock as selected by instructor
Safety glasses

B. Procedure

Note: The illustrations and procedures in this job sheet are adapted from materials originally published by the Research and Curriculum Unit for Vocational-Technical Education, College of Education, Mississippi State University, Mississippi State, MS, and are reprinted with permission.

☐ 1. Put on safety glasses.

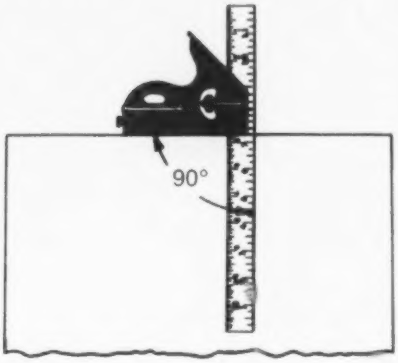
☐ 2. Place flat metal stock on a clean working area.

☐ 3. Butt the flat part of the handle along the upper edge of the metal stock so the scale forms a 90° angle down the surface of the metal.

☐ 4. Loosen the thumb screw on the bevel and move the scale down the metal to a point where it indicates exactly 6″, then tighten the thumb screw.

Job Sheet 2

☐ 5. Mark the 6″, 90° angle with soapstone.

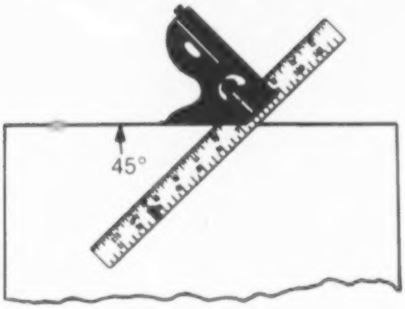


☐ 6. Have your instructor check for an exact 90° angle and a distance of exactly 6″.

☐ 7. Butt the flat part of the handle along the upper edge of the metal stock so the scale forms a 45° angle down and across the surface of the metal.

☐ 8. Loosen the thumb screw on the combination square and move the scale down the metal to a point where it indicates exactly 6″, then tighten the thumb screw.

☐ 9. Mark the 6″, 45° angle with soapstone.



☐ 10. Have your instructor check for an exact 45° angle and a distance of exactly 6″.

☐ 11. Loosen the thumb screw and slide the scale out the 90° side of the handle to prepare for marking parallel lines on the metal.

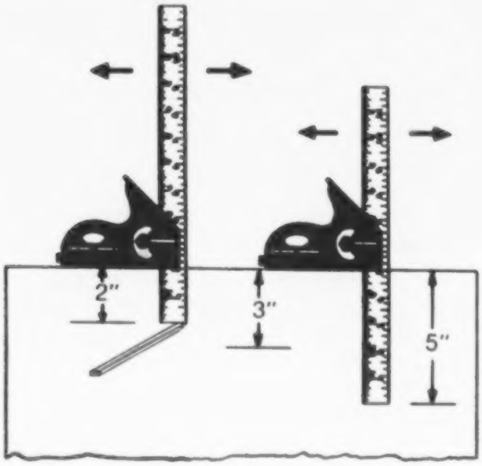
☐ 12. Place the scale on the 2″ mark and tighten the thumb screw.

Job Sheet 2

☐ 13. Mark the 2″ distance in two places along the left and right side of the metal.

☐ 14. Reset the scale at the 3″ mark and mark the 3″ distance at two places along the left and right side of the metal.

☐ 15. Reset the scale at the 5″ mark and mark the 5″ distance at two places along the left and right side of the metal.



☐ 16. Remove the combination square.

☐ 17. Line up the framing square along both 2″ marks and draw a straight line across the metal with soapstone.

☐ 18. Line up the framing square along both 3″ marks and draw a straight line across the metal with soapstone.

☐ 19. Line up the framing square along both 5″ marks and draw a straight line across the metal with soapstone.

☐ 20. Have your instructor check your work for parallel lines across the metal at points exactly 2″, 3″, and 5″ from the top.

☐ 21. Return tools and materials to proper storage areas.

Evaluator's comments: ____

____

____

Welding Print Reading
Unit 6

Objective Sheet

Unit Objective

After completing this unit, the student should be able to read, interpret, and construct top, side, and front views of objects, and interpret tolerance dimensions in decimals, fractions, and degrees. The student will demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to welding print reading with their correct definitions.
2. Match basic lines with their uses.
3. Identify basic views.
4. Differentiate between isometric and oblique drawings.
5. Solve problems relating to dimensioning.
6. Solve problems relating to tolerancing.
7. Differentiate between methods of dimensioning.
8. Select true statements about bevels and chamfers.
9. Complete statements about reduction and enlargement scales.
10. Identify types of holes.
11. Differentiate between types of threads.
12. Identify types of section views.
13. Complete statements about other symbols.
14. Complete statements about structural shapes.

Objective Sheet

15. Select true statements about requirements for a formal bill of material.

16. Complete statements about requirements for an informal bill of material.

17. Construct a top view. (Assignment Sheet 1)

18. Construct a front view. (Assignment Sheet 2)

19. Construct a right side view. (Assignment Sheet 3)

20. Construct missing hidden lines. (Assignment Sheet 4)

21. Construct missing visible and hidden lines. (Assignment Sheet 5)

22. Make a three-view sketch. (Assignment Sheet 6)

23. Construct adjacent parts in an assembly section. (Assignment Sheet 7)

24. Interpret tolerance dimensions in decimals, fractions, and degrees. (Assignment Sheet 8)

Welding Print Reading
Unit 6

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Formal Bill of Material (Objective 15)
   TM 2—Informal Bill of Material (Objective 16)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheets. Review criteria for evaluation of these activities.

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

Suggested Activities

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skills have been adapted by MAVCC.

1. Invite the drafting instructor at your school to demonstrate to the class some of the basic drafting skills they can use to help make the assignment sheets both easier and accurate. Skill area: **learning to learn**.

2. Check around your school or with local architects for construction prints that call for welding activity. Share the print(s) with the class and point out how the lines and symbols they'll be learning in this unit are applied in the real world. Skill area: **learning to learn**.

3. Invite a local or area welding shop operator or an area fabricator who uses welders in industry or construction. Ask the operator to talk to the students about the need for print reading abilities and what those abilities can add to a person's job-getting skills and income level. Skill area: **learning to learn**.

4. Notify students that skills learned in this unit of instruction will be required to complete activities in the next unit, "Basic Welding Joints and Symbols." Students will be challenged to read a welding print complete with welding symbols. Both print reading capabilities and welding symbol interpretation are required when working with workplace welding prints. The two are presented together in the next unit, and students should be prepared to exercise print reading skills developed from study and work with this unit. Skill area: **learning to learn**.

References Used in Developing This Unit

1. Schertz, Karen. *Basic Drafting.* Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1990.

2. Volume 1, Welding Technology Welding Handbook, 8th ed. Miami, FL: American Welding Society, 1987.

Suggested Activities

3. Volume 2, Welding Technology Welding Processes, 8th ed. Miami, FL: American Welding Society, 1989.

4. Fortney, Clarence and Mike Gregory. *Welding Blueprint Reading and Layout*. Stillwater, OK: The Mid-America Vocational Curriculum Consortium, 1984.

5. *The Procedure Handbook of Arc Welding*. Cleveland, OH: The Lincoln Electric Company, 1973.

Suggested Supplemental Resources

1. *Blueprint Reading for Welders and Fitters* is a videocassette tape produced by the Hobart School of Welding. The production covers 13 topics and is available in ½" VHS and other formats. The program comes complete with an instructor's guide. For information:

   Hobart School of Welding Technology
   Trade Square East
   Troy, OH 45373
   513-332-5217

2. *Welding Print Reading* is a 1984 publication by Goodheart-Wilcox Co. The 208-page text by John R. Walker is designed as a self-study course ranging from basics to specialized symbols and notations. Text is available from the publisher or from the American Welding Society.

3. *Bludeprint Reading and Sketching for Welders* is a 300-page Prentice Hall text published in 1987. The author, Nino Marion covers basic print reading and advances on to typical prints that welders encounter in the trade. Text is available from the publisher or from the American Welding Society.

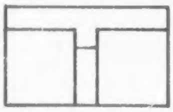
4. Because welding print reading requires interpreting welding symbols, students should complete the next unit of instruction before attempting to interpret a print and its associated welding procedures. So, although this unit is about welding print reading, the assignment sheet designed to evaluate student skills appears in the next unit, "Basic Welding Joints and Symbols." Remind students of this special arrangement. It promotes continuity between two closely-related units of instruction. (**Foundation Skills, science**)

Welding Print Reading
Unit 6

Answers to Assignment Sheets

Assignment Sheet 1

1.



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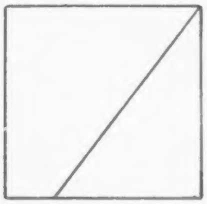

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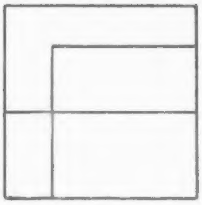

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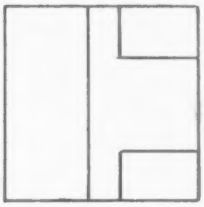

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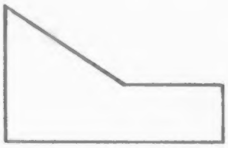

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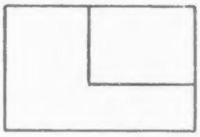

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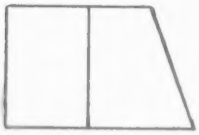
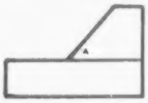


Answers to Assignment Sheets

Assignment Sheet 3

1.



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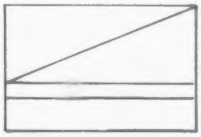

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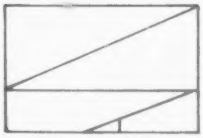

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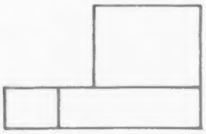

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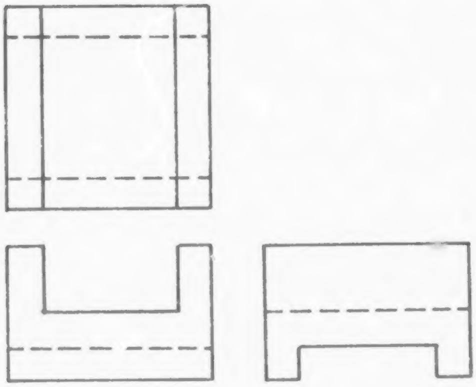

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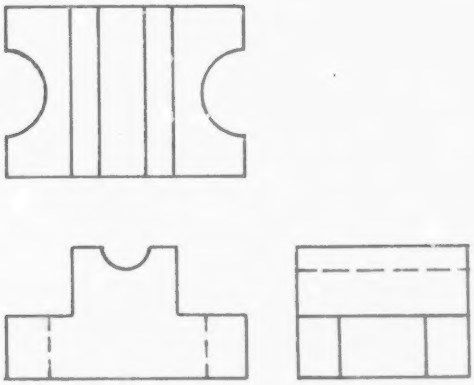
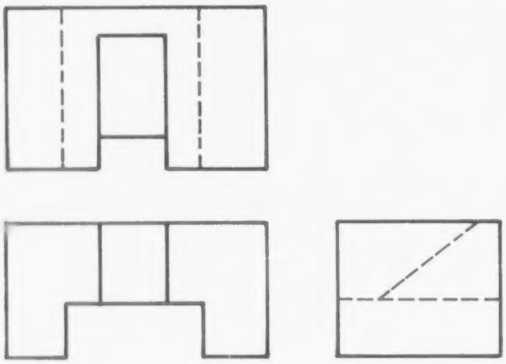


Answers to Assignment Sheets

3.



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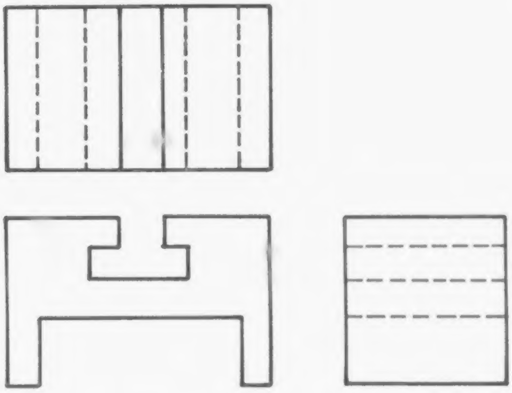

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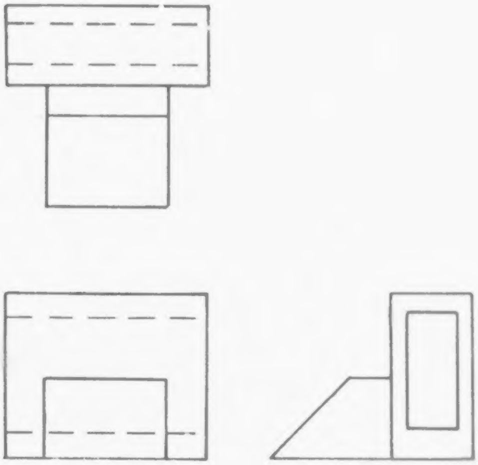

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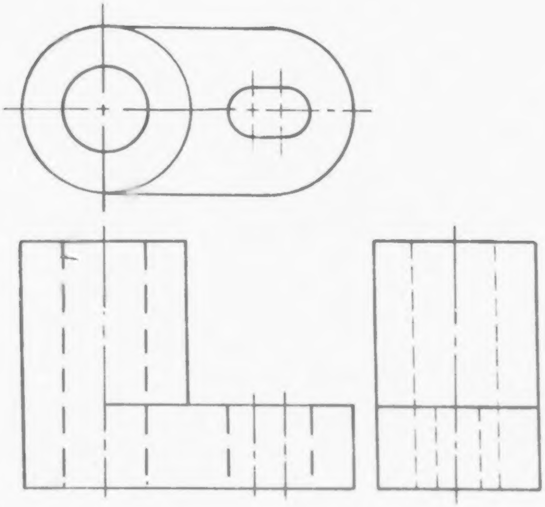

Answers to Assignment Sheets

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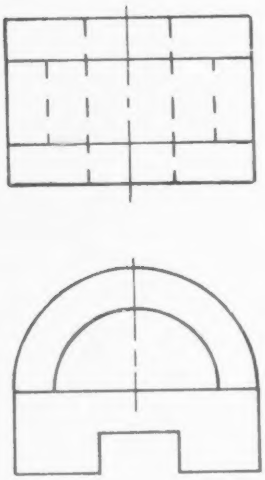

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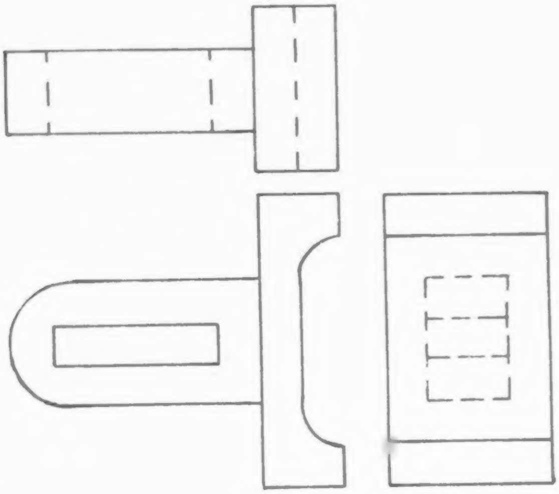

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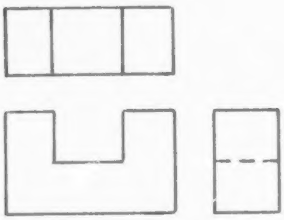

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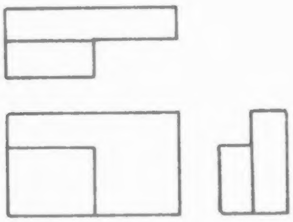

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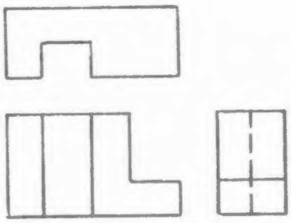

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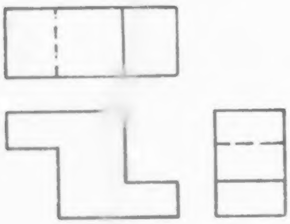

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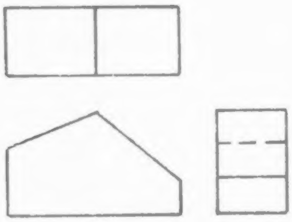

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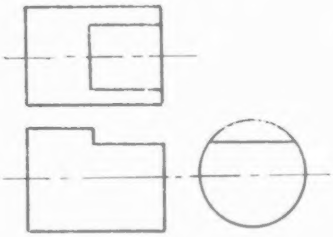
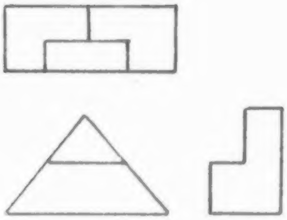


Answers to Assignment Sheets

11.



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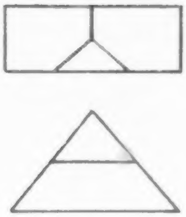

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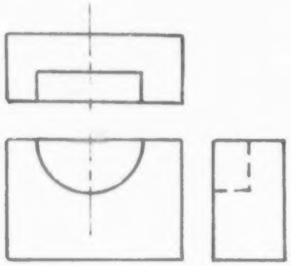

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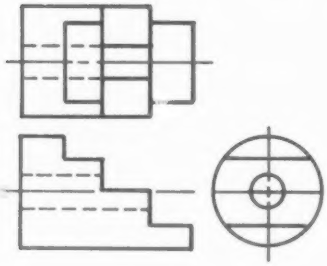

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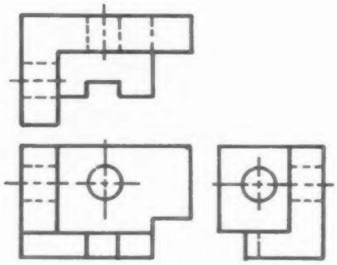

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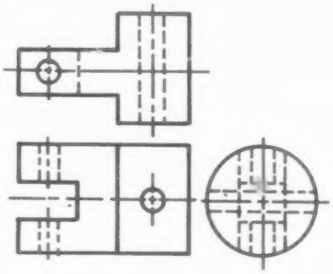
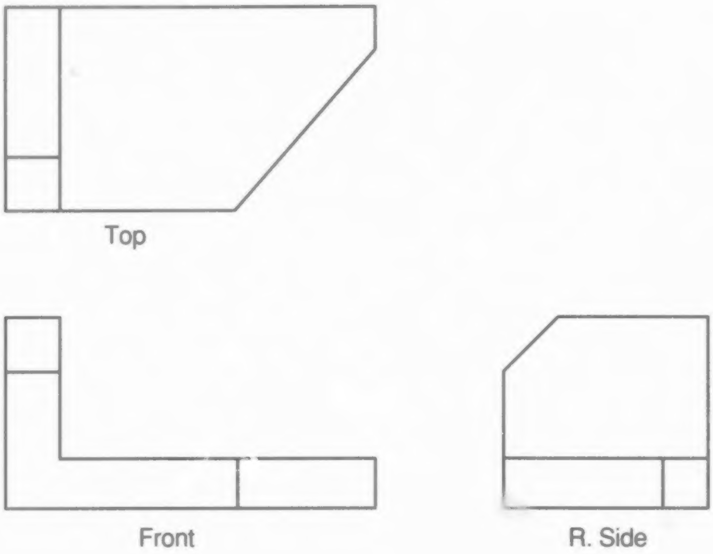


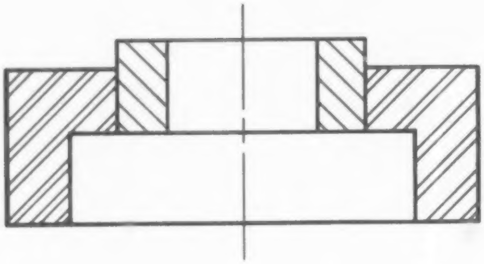
Assignment Sheet 6


Top
Front
R. Side

Answers to Assignment Sheets

Assignment Sheet 7

1.



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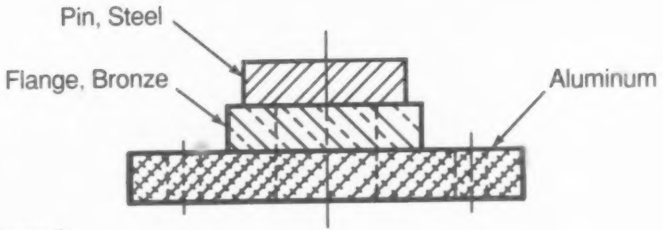


Assignment Sheet 8

1.	Maximum limit	.375
	Minimum limit	.372
	Total tolerance	.003
2.	Maximum limit	1.742
	Minimum limit	1.738
	Total tolerance	.004
3.	Maximum limit	0.995
	Minimum limit	0.990
	Total tolerance	.005
4.	Maximum limit	6⅞"
	Minimum limit	6⅜"
	Total tolerance	½"
5.	Maximum limit	8 13/32"
	Minimum limit	7 31/32"
	Total tolerance	7/16"
6.	Maximum limit	4′ 6 41/64"
	Minimum limit	4′ 6 31/64"
	Total tolerance	5/32"
7.	Maximum limit	92°
	Minimum limit	87°
	Total tolerance	5°
8.	Maximum limit	111° 7′
	Minimum limit	110° 13′
	Total tolerance	54′
9.	Maximum limit	125° 3′
	Minimum limit	117° 41′
	Total tolerance	7° 22′

Welding Print Reading
Unit 6

Answers to Written Test

1. a. 3
   b. 6
   c. 7
   d. 4
   e. 9
   f. 2
   g. 8
   h. 1
   i. 5

2. a. 8
   b. 4
   c. 6
   d. 11
   e. 1
   f. 12
   g. 5
   h. 9
   i. 2
   j. 7
   k. 10
   l. 3

3. a. 4
   b. 3
   c. 1
   d. 2
   e. 7
   f. 6
   g. 5
   h. 8

4. b

5. a. 3
   b. 2
   c. 2

6. a. 3
   b. 2
   c. 1

7. b

8. b

9. a. 2×, 3×, 4×, etc.
   b. In fractions and inches

10. a. 2
    b. 4
    c. 1
    d. 3

11. a. E
    b. I

12. a. 3
    b. 2
    c. 4
    d. 1

Answers to Written Test

13. a. Composition of materials
b. Lines
c. Finished
d. A knurling symbol
e. ×

14. a. Structural fabrication
b. Miniature pictorials
c. Inside
d. Outside
e. Smooth continuation

15. a, b, d, e

16. a. In numerical order
b. In numerical sequence
c. Number
d. Of parts that require such information
e. Better understanding

Welding Print Reading
Unit 6

Written Test

Name ______________________________ Score ____________

1. Match the term on the right with their correct definitions.

______a. A copy of an original drawing that uses lines, symbols, and other pictorial elements to show how a part or assembly should be made

______b. An adaption of a print in total or in part to detail fabrication requirements of specific components in a production or job shop environment

______c. Information in capital letters or numbers concerning details of construction

______d. A listing of specific materials welding process, electrode, rod, or other specific requirements

______e. A pictorial view of a standard shape, line, material, or other items of information

______f. A set of lines, arrows, and dashes used to represent size, shape, location, or composition of an object

______g. Numbers used to define size and location

______h. A pictorial or orthographic projection of an object that displays its complex size and shape from all necessary sides

______i. The total amount by which a specific dimension is permitted to vary in maximum and minimum limits usually expressed as a plus or minus value

1. Basic views
2. Basic lines
3. Welding print
4. Specifications
5. Tolerance
6. Working drawing
7. Notes
8. Dimensions
9. Symbol

Written Test

2. Match basic lines with their uses. Write the letter of the correct definition in the appropriate blank.

______a. Thick, unbroken lines used to indicate the visible shape of an object

______b. Medium thickness lines of short dashes used to indicate interior details of an object that are not visible

______c. Thin lines that have dimensions inserted at the center and are terminated by arrowheads at each end

______d. Thin lines used for placing limits on dimension; these do not touch, but extend from the height, width, and length of an object

______e. Thin lines with alternating long and short dashes used to indicate the center of objects, holes, arcs, and symmetrical shapes; also used as extension lines for dimensions

______f. Thick wavy lines used to indicate that an object has been slightly shortened to conserve space but still provide clarity

______g. Thin lines with sharp spur-shaped variations above and below the line to indicate that an object has been greatly shortened to conserve space

______h. Fine, straight lines with an arrow or a dot at one end which points directly to a surface area or specific point for the purpose of dimensioning of adding a note

1. Center lines
2. Cutting plane lines
3. Phantom lines
4. Hidden lines
5. Long break lines
6. Dimension lines
7. Viewing plane lines
8. Object or visible lines
9. Leader lines
10. Section lines
11. Extension lines
12. Short break lines

Written Test

______i. Thick, broken line of two short and one long sections used to indicate an imaginary cut through an object, with arrowheads terminating at right angles to the line to indicate direction in which the cut area should be viewed

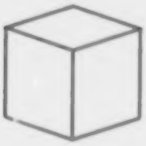
______j. Lines that look like cutting plane lines, but instead of cutting through a shape, they are used to indicate that the surface should be viewed in the direction of the arrow heads

______k. Series of fine lines used to indicate the area of an imaginary cut made by a cutting plane line, and are normally identified by letters that reference the cutting plane letters

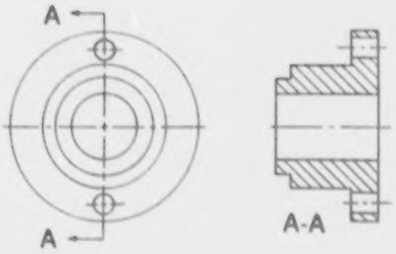
______l. Thin lines with alternating long and short dashes to indicate other positions to which a part or an object can be moved

3. Identify basic views. Place the number denoting the type of view below the appropriate graphic.

1. Detail view
2. Orthographic projection, top view
3. Full section view
4. Pictorial view
5. Orthographic projection front view
6. Partial view



a.______

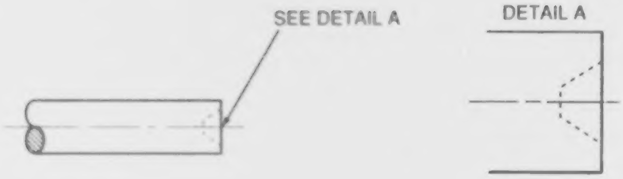


b.______

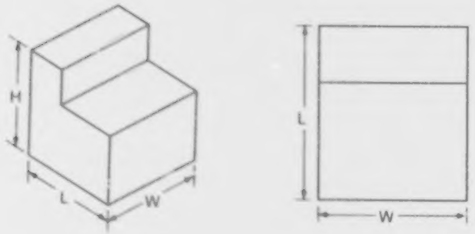
Written Test

7. Orthographic projection side view

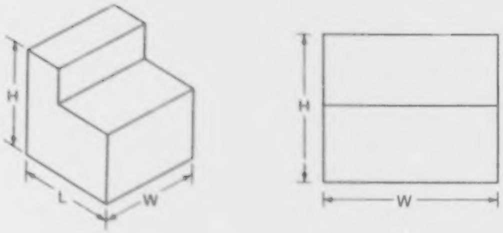
8. Auxiliary view


SEE DETAIL A
DETAIL A

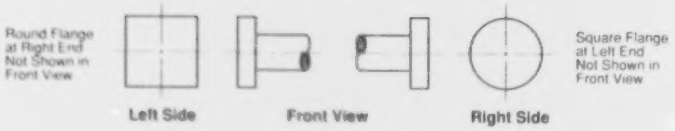
c.______



d.______



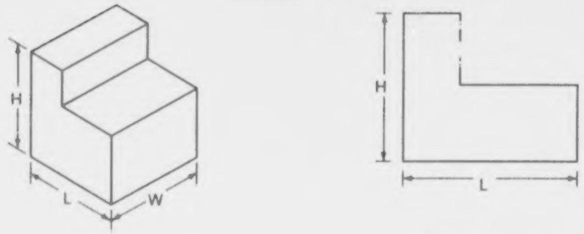
e.______


Round Flange at Right End Not Shown in Front View
Left Side
Front View
Right Side
Square Flange at Left End Not Shown in Front View

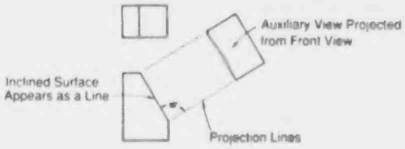
f.______

Written Test

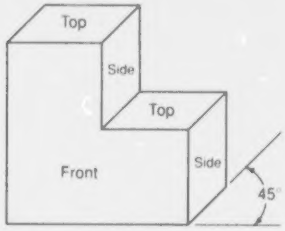
g.______



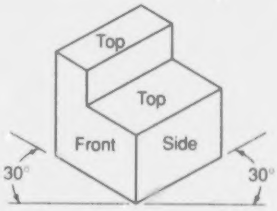
h.______


Auxiliary View Projected from Front View
Inclined Surface Appears as a Line
Projection Lines

4. Differentiate between isometric and oblique drawings. Select the isometric drawing from the following graphics by placing an "X" below it.


Top
Side
Top
Front
Side
45°

a.______


Top
Top
Front
Side
30°
30°

b.______

5. Solve problems relating to dimensioning. Select the best answer for each of the following conditions.

   a. Whole numbers and fractions frequently used in welding dimensioning are used when:

      (1) Precision is required
      (2) The print is large enough to facilitate the numbers.
      (3) Precise size is extremely remote.

   b. Decimals are used in machine shop dimensioning when:

      (1) A small print demands smaller numbers.
      (2) Close tolerances are necessary.
      (3) Decimals are used in other parts of the print.

   c. Angular dimensioning helps find the included angle which is expressed:

      (1) As a percentage of a horizontal plane.
      (2) As degrees or portions of degrees.
      (3) A groove or fillet construction.

Written Test

6. Solve problems related to tolerancing. Select the best answer for each of the following problems.

   a. You are working with a print that uses decimals for tolerancing, so what items do you expect to see?

      (1) Maximum and minimum limits expressed as ± ⅛".
      (2) Maximum and minimum limits expressed as ± 2°.
      (3) Maximum and minimum limits expressed as ± .010.

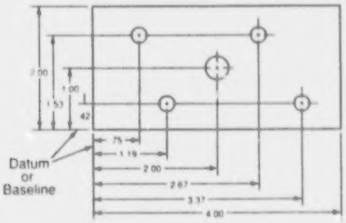
   b. A co-worker reading a print says that since the maximum tolerance stated is .010 and the minimum tolerance stated is also .010, then the total tolerance is obviously .010. Considering the stated tolerances, your co-workers is:

      (1) Right, because both tolerances are the same.
      (2) Wrong, because the two tolerances should be added together to produce total tolerance.
      (3) Wrong, because if maximum and minimum limits are given, total tolerance wouldn't be used.

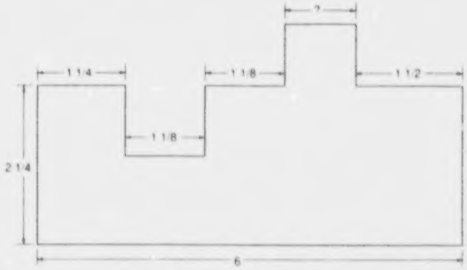
   c. A co-worker tells you that working with tolerances stated in degrees is easy because it's stated in hours and minutes, just like telling time. Your co-worker is:

      (1) Wrong, because degrees and minutes used in tolerancing refer to distance, not to time.
      (2) Right, because all complete circles have 360°.
      (3) Wrong, because degrees and minutes used in tolerancing are the same as used for telling time, but they are used in a special way.

7. Differentiate between methods of dimensioning. Place an "X" below the following illustration that reflects conventional dimensioning.



a.______



b.______

Written Test

8. Select true statements about bevels and chamfers. Place an "X" beside each true statement.

   ______a. A bevel is a sloping surface which always extends the full length of an edge.

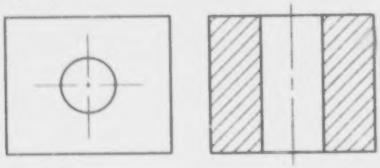
   ______b. Chamfer is another term for bevel, but chamfer is normally used in machine shop practice while bevel is used in welding applications.

9. Complete statements about reduction and enlargement scales. Circle the material that best completes each statement.

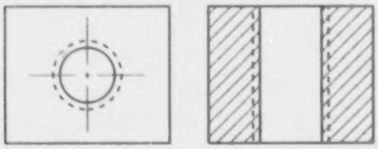
   a. An enlargement scale presents an object larger than its actual size, and is usually expressed as (**twice triple, quadruple, etc.**) (**2×, 3×, 4×, etc.**).

   b. A reduction scale presents and object smaller than its actual size, and is usually expressed (**in decimals**) (**in fractions and inches**).

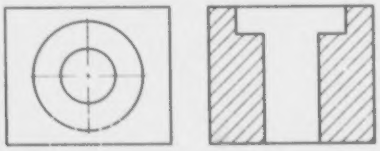
10. Identify types of holes. Place the number denoting the type of hole below the appropriate graphic.



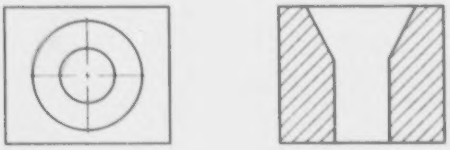
a.______



b.______



c.______

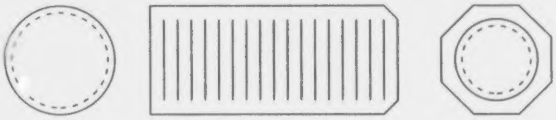


d.______

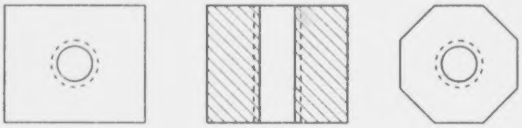
1. Counterbore
2. Drilled
3. Countersunk
4. Threaded

Written Test

11. Differentiate between types of threads. Place an "I" beneath the graphic of an internal thread and an "E" beneath the graphic of an external thread.



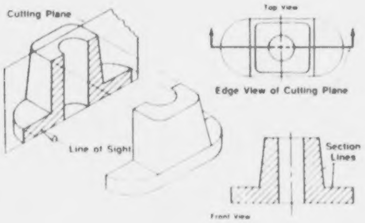
a.______



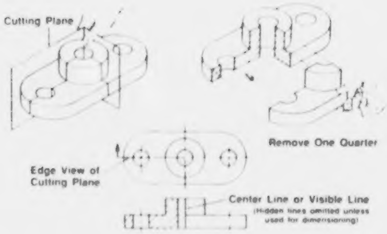
b.______

12. Identify types of sections views. Place the number denoting the type of section view below the appropriate graphic.

1. Revolved section
2. Half section
3. Full section
4. Offset section

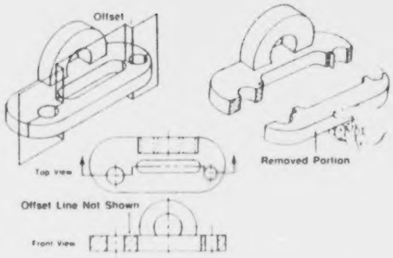

Cutting Plane
Top View
Edge View of Cutting Plane
Line of Sight
Section Lines
Front View

a.______

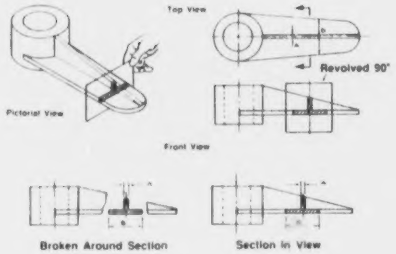

Cutting Plane
Remove One Quarter
Edge View of Cutting Plane
Center Line or Visible Line
(Hidden lines omitted unless used for dimensioning)

b.______

Written Test


Offset
Removed Portion
Top View
Offset Line Not Shown
Front View

c.______


Top View
Revolved 90°
Pictorial View
Front View
Broken Around Section
Section In View

d.______

13. Complete statements about other symbols. Circle the material that best completes each statement.

    a. Material symbols use cross hatching lines to indicate (**planes on a surface**) (**composition of materials**).

    b. Stock components are depicted with (**pictorials**) (**lines**) that show their structural shapes.

    c. Machine symbols indicate to what degree of smoothness a surface should be (**prepared**) (**finished**).

    d. (**An expanded metal symbol**) (**A knurling symbol**) is used to indicate that a gripping surface should be provided on a normally smooth surface.

    e. An (**x**) (**s**) through a part indicates that an object is square when viewed from a side view.

Written Test

14. Complete statements about structural shapes. Circle the material that best completes each statement.

    a. Many structural shapes are common to all varieties of (**structural fabrication**) (**welding materials**).

    b. The symbols for structural shapes are (**isometric drawings**) (**miniature pictorials**) of the shapes themselves.

    c. The fillet shape is an (**inside**) (**outside**) corner of a 90° angle whether machined smoothly or welded.

    d. The round shape is an (**inside**) (**outside**) 90° corner.

    e. A runout is a (**smooth continuation**) (**slight elevation**) of a change in direction to avoid a weakened area that could result from an abrupt change.

15. Select true statements about requirement for a formal bill of materials. Place an "X" beside each true statement.

    ______a. Should list the name of the firm that made the blueprint or drawing, the name of the form for whom the drawing was made, and list the drafter's initials, date of drawing, and initials of the drafting supervisor who checked the print

    ______b. Should list the part name last and items that define the part should precede the name

    ______c. Should detail parts individually so they will be easy to purchase.

    ______d. Should specify quantities required, sizes, required and information relating specific grades, brand names, or standards to which the part must comply

    ______e. Should clarify with notes important information taken directly from the blueprint for drawing, and related references to job number, location, and other materials necessary to properly relate the material list to the specific application that the print calls for

16. Complete statements about the requirements for an informal bill of material. Circle the information that best completes each statement.

    a. It should arrange the materials (**in numerical order**) (**alphabetically**).

    b. It should identify materials by a mark number (**in numerical sequence**) (**alphabetically**).

Written Test

c. It should specify the (**number**) (**quality**) required for each part.

d. It should clearly define size or dimension (**of all parts**) (**of parts that require such information**).

e. It should note any other information that helps to clarify quality of material or elements in the original print or drawing that should be reference for (**better understanding**) (**special order**) of what the part or material is used for.

Welding Print Reading
Unit 6

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Construct a Top View. Rating ______

Comments: ______________________

Assignment Sheet 2—Construct a Front View Rating ______

Comments: ______________________

Assignment Sheet 3—Construct a Right Side View Rating ______

Comments: ______________________

Assignment Sheet 4—Construct Missing Hidden Lines Rating ______

Comments: ______________________

Assignment Sheet 5—Construct Missing Visible and Hidden Lines Rating ______

Comments: ______________________

Assignment Sheet 6—Make a Three-View Sketch Rating ______

Comments: ______________________

Assignment Sheet 7—Construct Adjacent Parts in an Assembly Section Rating ______

Comments: ______________________

Unit Evaluation Form

Assignment Sheet 8—Interpret tolerance dimensions in decimals, fractions, and degrees Rating ______

Comments: ____

____

Written Test Scores

Pretest ______ Posttest ______ Other ______

Other ____

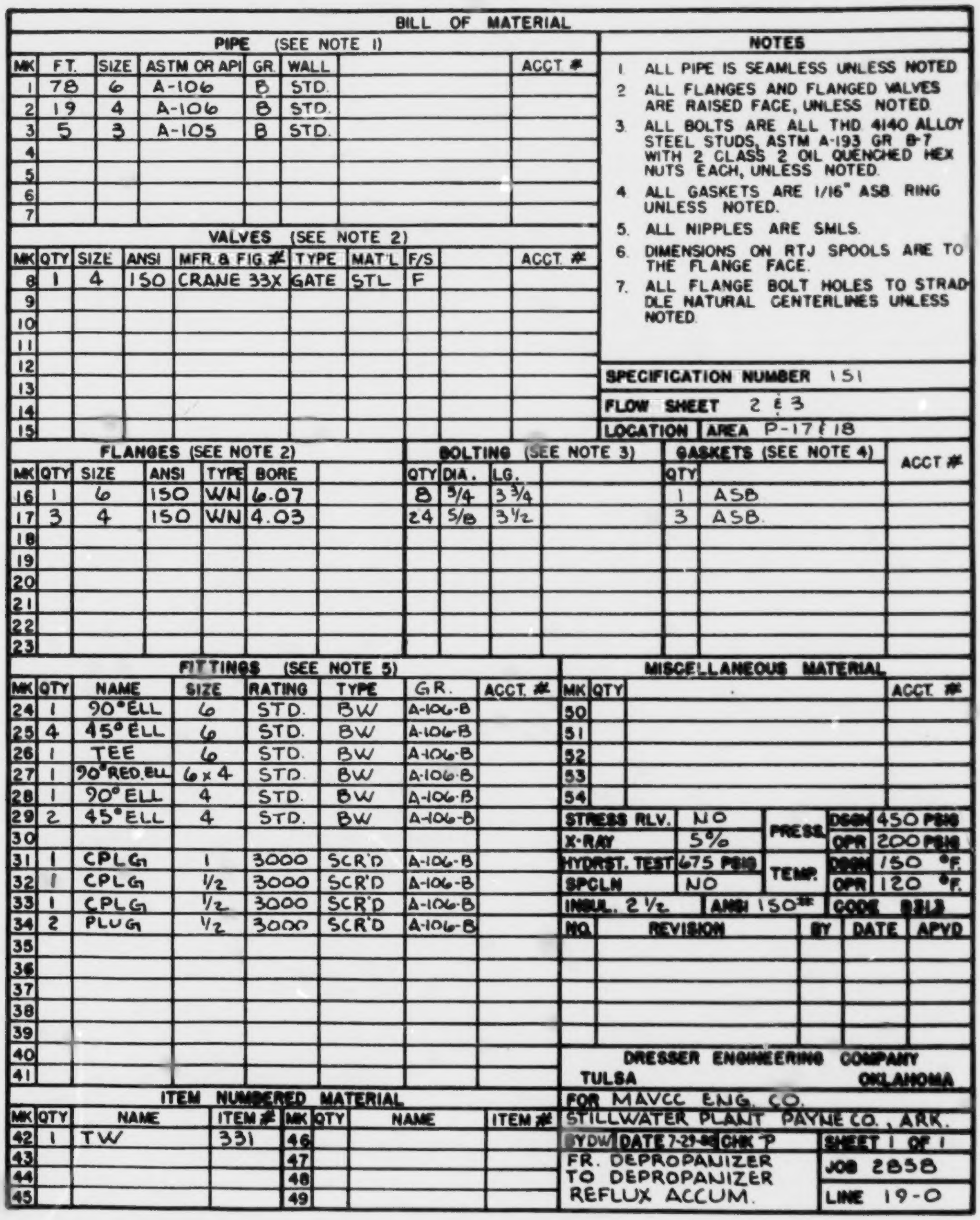
____

Teacher Signature ______________________ Date ____________

Student Signature ______________________ Date ____________

*Permission to duplicate this form is granted.

Formal Bill of Material



BILL OF MATERIAL

PIPE (SEE NOTE 1)

MK	FT.	SIZE	ASTM OR API	GR.	WALL		ACCT #
1	78	6	A-106	B	STD.		
2	19	4	A-106	B	STD.		
3	5	3	A-105	B	STD.		
4							
5							
6							
7							

VALVES (SEE NOTE 2)

MK	QTY	SIZE	ANSI	MFR. & FIG #	TYPE	MAT'L	F/S		ACCT #
8	1	4	150	CRANE 33X	GATE	STL	F		
9									
10									
11									
12									
13									
14									
15									

NOTES

1. ALL PIPE IS SEAMLESS UNLESS NOTED
2. ALL FLANGES AND FLANGED VALVES ARE RAISED FACE, UNLESS NOTED.
3. ALL BOLTS ARE ALL THD 4140 ALLOY STEEL STUDS, ASTM A-193 GR B-7 WITH 2 CLASS 2 OIL QUENCHED HEX NUTS EACH, UNLESS NOTED.
4. ALL GASKETS ARE 1/16" ASB RING UNLESS NOTED.
5. ALL NIPPLES ARE SMLS.
6. DIMENSIONS ON RTJ SPOOLS ARE TO THE FLANGE FACE.
7. ALL FLANGE BOLT HOLES TO STRADDLE NATURAL CENTERLINES UNLESS NOTED.

SPECIFICATION NUMBER 151

FLOW SHEET 2 & 3

LOCATION AREA P-17 & 18

FLANGES (SEE NOTE 2)							BOLTING (SEE NOTE 3)				GASKETS (SEE NOTE 4)		ACCT #
MK	QTY	SIZE	ANSI	TYPE	BORE		QTY	DIA.	LG.		QTY		
16	1	6	150	WN	6.07		8	3/4	3 3/4		1	ASB	
17	3	4	150	WN	4.03		24	5/8	3 1/2		3	ASB.	
18													
19													
20													
21													
22													
23													

FITTINGS (SEE NOTE 5)

MK	QTY	NAME	SIZE	RATING	TYPE	GR.	ACCT. #
24	1	90° ELL	6	STD.	BW	A-106-B	
25	4	45° ELL	6	STD.	BW	A-106-B	
26	1	TEE	6	STD.	BW	A-106-B	
27	1	90° RED. ELL	6 x 4	STD.	BW	A-106-B	
28	1	90° ELL	4	STD.	BW	A-106-B	
29	2	45° ELL	4	STD.	BW	A-106-B	
30							
31	1	CPLG	1	3000	SCR'D	A-106-B	
32	1	CPLG	1/2	3000	SCR'D	A-106-B	
33	1	CPLG	1/2	3000	SCR'D	A-106-B	
34	2	PLUG	1/2	3000	SCR'D	A-106-B	
35							
36							
37							
38							
39							
40							
41							

MISCELLANEOUS MATERIAL

MK	QTY		ACCT. #
50			
51			
52			
53			
54			

STRESS RLV.	NO	PRESS.	DSGN	450 PSIG
X-RAY	5%		OPR	200 PSIG
HYDRST. TEST	675 PSIG	TEMP.	DSGN	150 °F.
SPCLN	NO		OPR	120 °F.
INSUL. 2 1/2	ANSI 150#		CODE B31.3	

NO.	REVISION	BY	DATE	APVD

ITEM NUMBERED MATERIAL

MK	QTY	NAME	ITEM #	MK	QTY	NAME	ITEM #
42	1	TW	331	46			
43				47			
44				48			
45				49			

DRESSER ENGINEERING COMPANY
TULSA OKLAHOMA

FOR MAVCC ENG. CO.

STILLWATER PLANT PAYNE CO., ARK.

BY DW | DATE 7-29-86 | CHK P | SHEET 1 OF 1

FR. DEPROPANIZER
TO DEPROPANIZER
REFLUX ACCUM.

JOB 2858

LINE 19-0

Informal Bill of Material

NO. REQ'D	MATERIAL	MK.
8	3/8" PL 10" x 8 1/2" S-A-36	1
2	3/8" PL 10" X 6 1/2" S-A-36	2
2	3/8" PL 10" X 6 1/4" S-A-36	3
2	3/8" PL 10" X 6 3/8" S-A-36	4
2	3/8" PL 10" x 8 3/8" S-A- 36	5
1	3/8" PL 10" X 6 3/8" SA-36	6
5	4 X 4 x 5/16" ∠ SA-36	7
5	DO DO	8
2	4X4 x 5/16" ∠ DO	9
2	DO DO	10
2	4 x 4 x 5/16" ∠ DO	11
2	DO DO	12
4	5X 5X 3/8 ∠ X 2'-5 1/2 DO	13
1	3/8" PL-10" X 6 1/2 DO	14
2	3/8" PL-10" X 6 3/8" DO	15
6	3/8" PL 19" X 6 1/2" DO	16
6	3/8" PL 7" X 27" -	17
20	3/8 PL 7" X 20" -	18
2	DAVIT PL (SEE C-18002-5)	DP
1	DAVIT WF (See c- 18002-5)	DW

Welding Print Reading
Unit 6

Information Sheet

1. **Terms and definitions**

   a. **Welding print** — A copy of an original drawing that uses lines, symbols, and other pictorial elements to show how a part or assembly should be made

   b. **Working drawing** — An adaption of a print in total or in part to detail fabrication requirements of specific components in a production or job shop environment

   c. **Notes** — Information in capital letters or numbers concerning details of construction

   d. **Specifications** — A listing of specific materials, welding process, electrode, rod, or other specific requirements

   e. **Symbol** — A pictorial view of a standard shape, line, material, or other items of information

   f. **Basic lines** — A set of lines, arrows, and dashes used to represent size, shape, location, or composition of an object

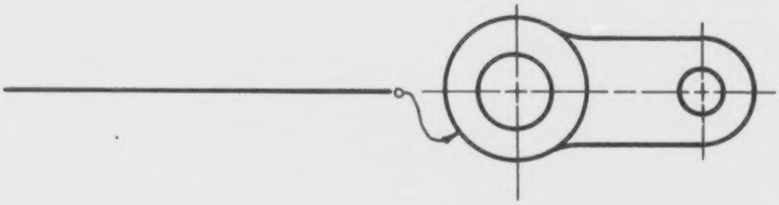
   g. **Dimensions** — Numbers used to define size and location

   h. **Basic views** — A pictorial or orthographic projection of an object that displays its complex size and shape from all necessary sides

   i. **Tolerance** — The total amount by which a specific dimension is permitted to vary in maximum and minimum limits usually expressed as a plus or minus value

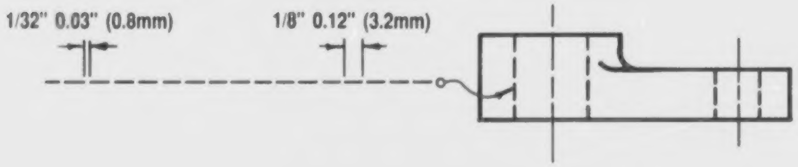
2. **Basic lines and their uses**

   a. **Object or visible lines** — Thick, unbroken lines used to indicate the visible shape of an object



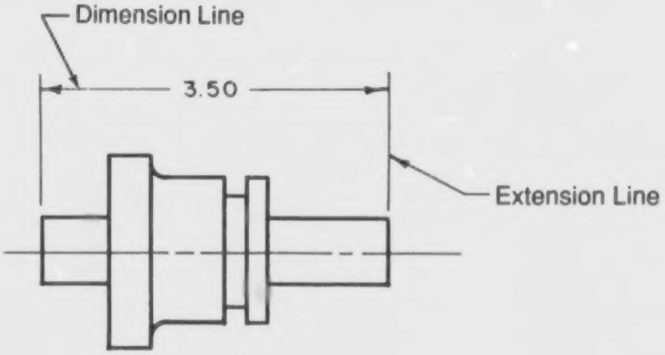
Information Sheet

b. **Hidden lines** — Medium thickness lines of short dashes used to indicate interior details of objects that are not visible

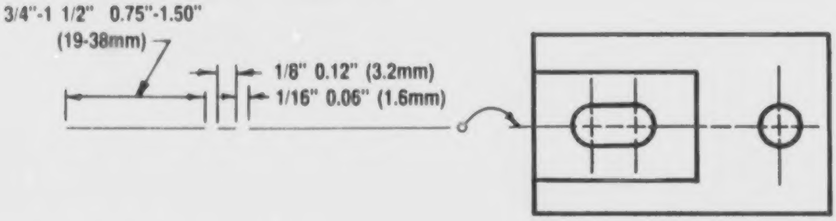

1/32" 0.03" (0.8mm)
1/8" 0.12" (3.2mm)

c. **Dimension lines** — Thin lines that have dimensions inserted at the center and are terminated by arrows at each end (see following graphic)

d. **Extension lines** — Thin lines used for placing limits on dimensions, they do not touch, but extend from the height, width, and length of an object (see following graphic)

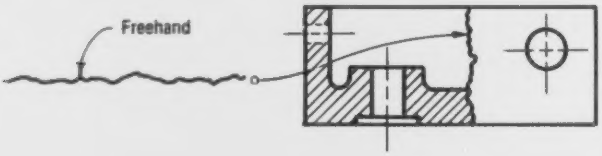

Dimension Line
3.50
Extension Line

e. **Center lines** — Thin lines with alternating long and short dashes used to indicate the center of objects, holes, arcs, symmetrical shapes, and also used for extension lines for dimensioning

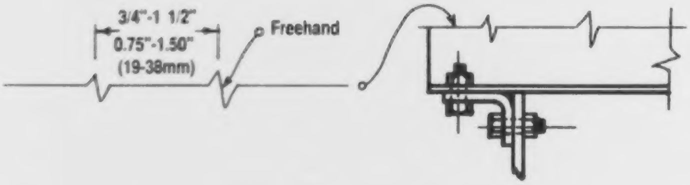

3/4"-1 1/2" 0.75"-1.50"
(19-38mm)
1/8" 0.12" (3.2mm)
1/16" 0.06" (1.6mm)

Information Sheet

f. **Short break lines** — Thick, way lines used to indicate that an object has been slightly shortened to conserve space but still provide clarity

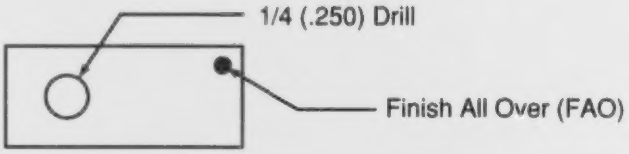


g. **Long break lines** — Thin lines with spur-shaped variations above and below the line to indicate that an object has been greatly shortened to conserve space

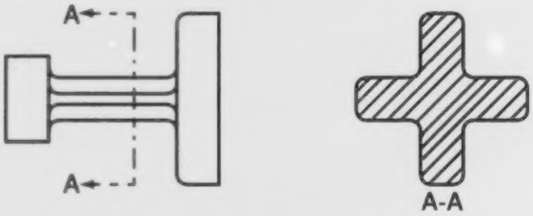


Note: Both long and short break lines are at points where shapes or features do not change.

h. **Leader lines** — Fine, straight lines with an arrow or a dot at one end which points directly to a surface area or specific point for the purpose of dimensioning or adding a note

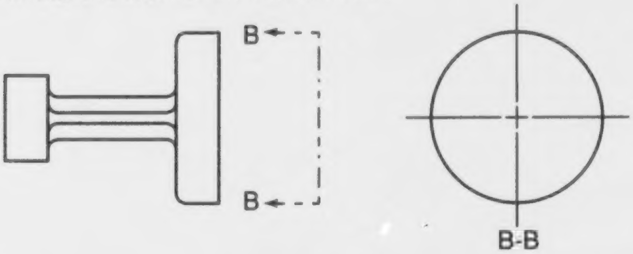


i. **Cutting plane lines** — Thick, unbroken lines of two short and one long sections used to indicate and imaginary cut through an object, with arrowheads terminating at right angles to the line to indicate direction in which the cut area should be viewed



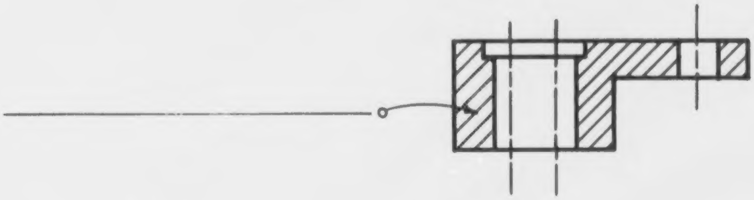
Information Sheet

j. **Viewing plane lines** — Lines that look like cutting plane lines, but instead of cutting through a shape, they are used to indicate that the surface should be viewed in the direction of the arrow heads

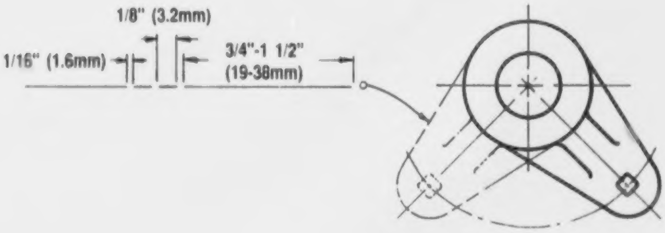


k. **Section lines** — Series of fine lines used to indicate the area of an imaginary cut made by a cutting plane line, and are normally identified by letters that reference the cutting plane letters

Note: Section lines are also used to denote material composition when different materials are used in manufacturing.



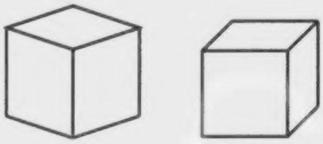
l. **Phantom lines** — Thin lines with alternating long and short dashes to indicate other positions to which a part or an object can be moved



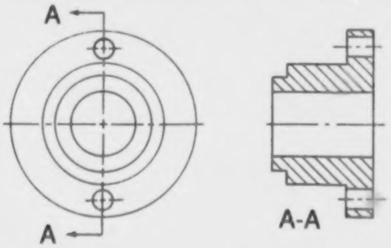
Information Sheet

3. Basic views

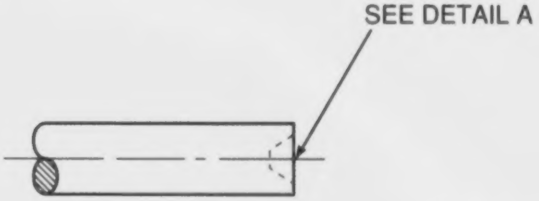
a. **Pictorial view** — Presents an object from a given angle as it appears visually, and helps a person form a better idea of an object's size, shape, and features

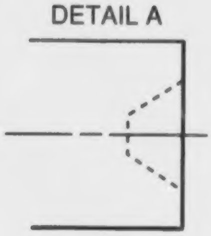


b. **Section view** — Presents an internal view of a specific section of a part so that shape, material, and other elements will be easier to visualize



c. **Detail view** — Presents an enlarged view of a specific portion of a part so that small details or features can be better visualized

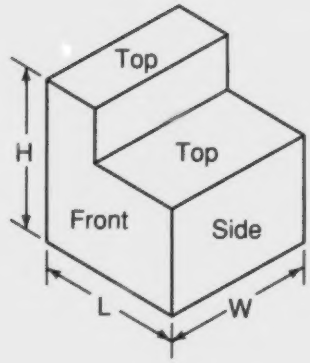


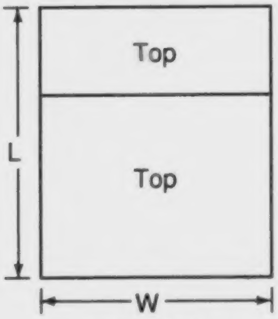


Information Sheet

d. Orthographic projection views

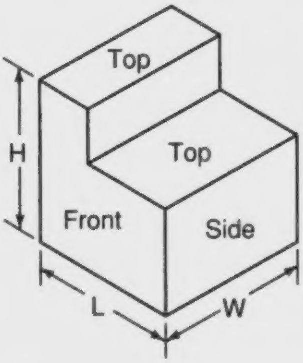
(1) **Top view** — presents a view that looks down on an object and provides definition of length and width, but does not show height

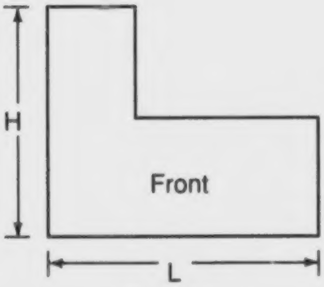

Top
H
Top
Front
Side
L
W



Top View

(2) **Front view** — Presents a view that shows the best shape of the object, but it does not necessarily represent the front of the object

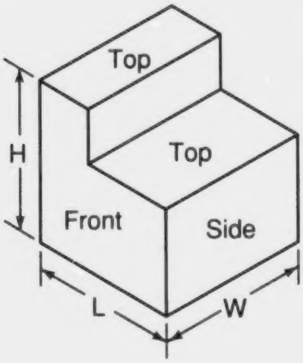

Top
H
Top
Front
Side
L
W

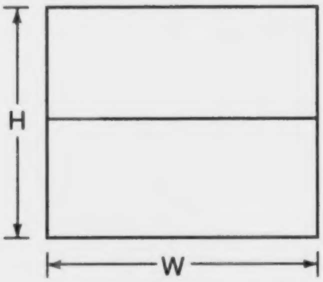


Front View

Information Sheet

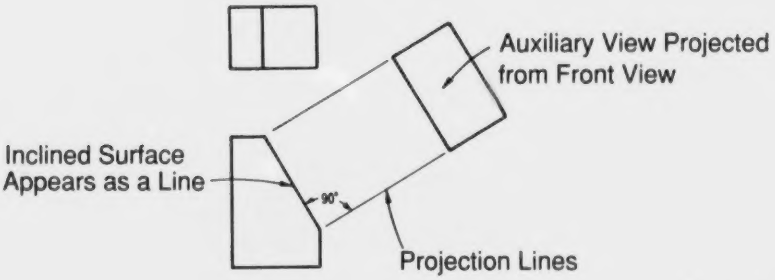
(3) **Side view** — Presents a view of an object from the left or right side and provides details that are not shown in other views


Top
Top
H
Front
Side
L
W

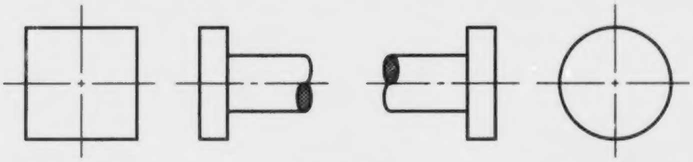


Right Side

(4) **Auxiliary view** — Presents a view projected from any view of a slanted surface to show true shape and size


Auxiliary View Projected from Front View
Inclined Surface Appears as a Line
90°
Projection Lines

(5) **Partial view** — Shows a difference in portions of an object when like front views are shown, but actually differs when side views are drawn



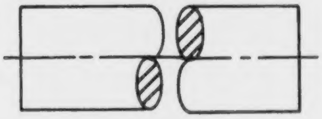
Round Flange at Right End Not Shown in Front View

Square Flange at Left End Not Shown in Front View

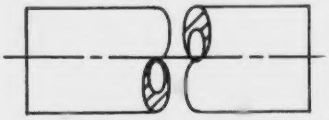
Left Side **Front View** **Right Side**

Information Sheet

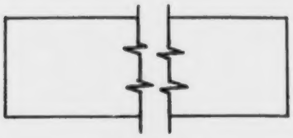
e. **Views with conventional breaks** — Used when an object has a uniform shape, but must be reduced to conform to space limitations



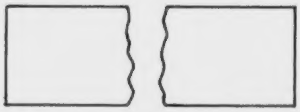
Round Solid Section



Pipe or Tubing



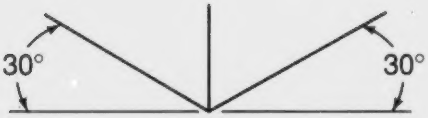
Long Break



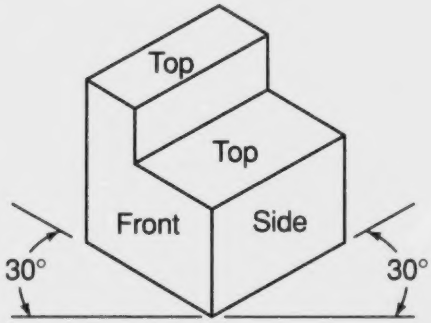
Short Break

4. **Isometric and oblique drawings**

a. **Isometric** — A drawing that has all its surfaces projected at 30 degree angles from a basic starting point that is called a crowsfoot

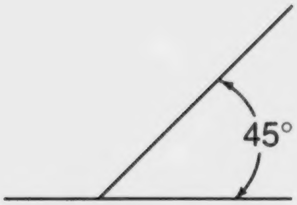


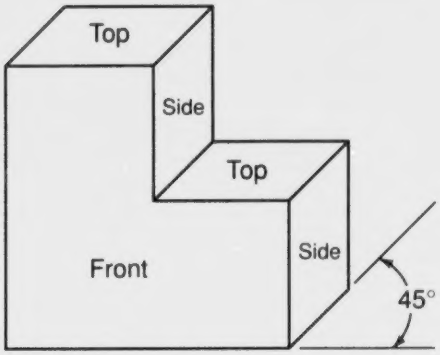
Crowsfoot



Information Sheet

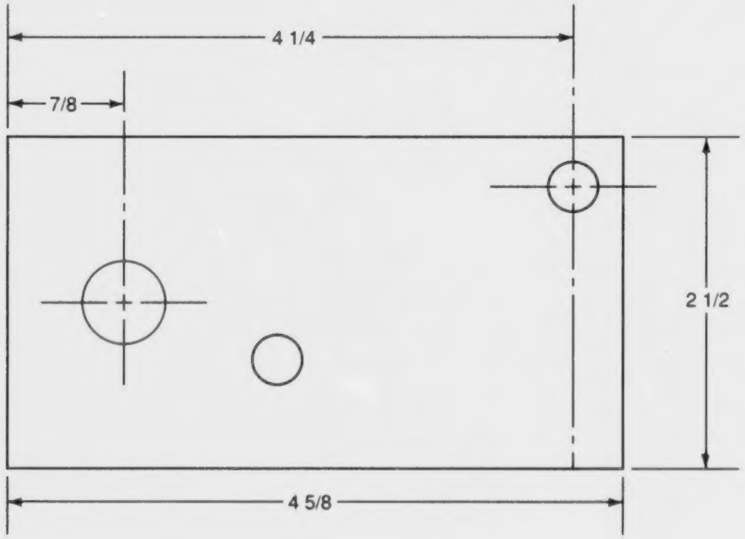
b. **Oblique** — A drawing that has its lines parallel to each other at 45 degree angles to the right or left, and normally drawn from the front or side view




Top
Side
Top
Front
Side
45°

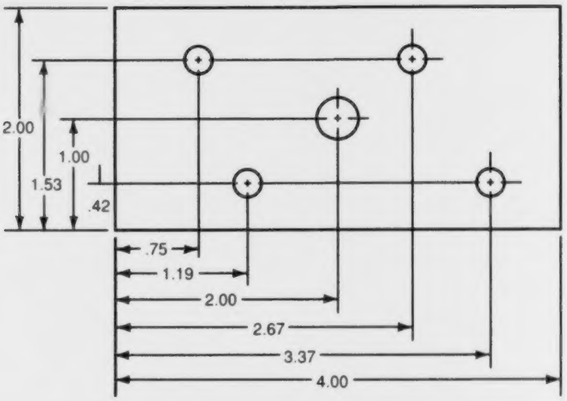
5. **Dimensioning**

a. **Whole numbers and fractions** — Used in combination such as 2½, 4⅝, and normally used in welding when precise size is extremely remote

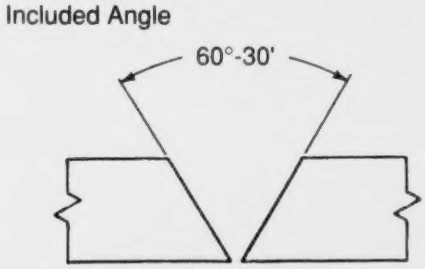

4 1/4
7/8
2 1/2
4 5/8

Information Sheet

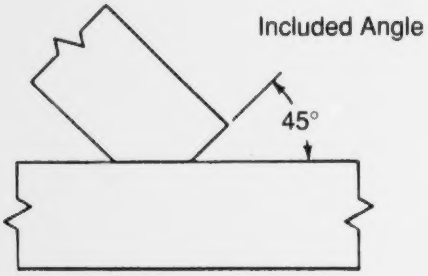
b. **Decimals** — Normally used in machine shop dimensioning when mating parts require precise measurements or when close tolerances are necessary



c. **Angular** — Used when a line is at an angle to a horizontal, vertical, or another angular line, and the angle is called the "included angle" which is expressed in degrees or portions of degrees



Angular-To-Horizontal Line
Degrees and Minutes



Angular-To-Horizontal Line

6. Tolerancing

a. Tolerancing with decimals means that dimensions are in decimal form and/usually tolerancing is stated as a plus or minus.

Example: 5.425 ± .010 would be read as: Five and 425 thousandths of an inch plus or minus ten thousandths of an inch. Expressed in decimals, the dimensions would be: Max. 5.425 + .010 = 5.435
Min. 5.425 − .010 = 5.415

b. Tolerance is sometimes stated as total tolerance which in the example above would be the total of .010 = .010 or .020.

Information Sheet

c. Tolerancing with fractions means that dimensions are in whole numbers, fractions, or combinations of both.

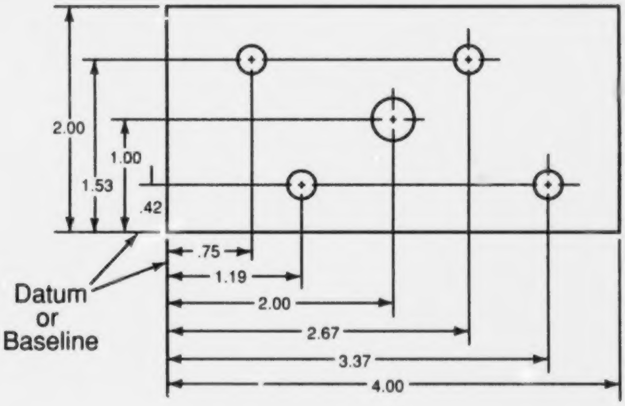
Example: $5\frac{5}{8}'' \pm \frac{1}{8}''$
Max. $5\frac{5}{8} + \frac{1}{8} = 5\frac{6}{8}$ or $5\frac{3}{4}$
Min. $5\frac{5}{8} - \frac{1}{8} = 5\frac{4}{8}$ or $5\frac{1}{2}$

d. Tolerancing with degrees means that dimensions are related to the 360 degrees in a circle with 60 minutes equalling 1 degree, and minutes, in this case, refer to distance, not time.

Example: 60 minutes = 1 degree and is notated at 60′
$45° \pm 2° 30'$
Max. $45° + 2° 30' = 47° 30'$
Min. $45° - 2° 30' = 42° 30'$

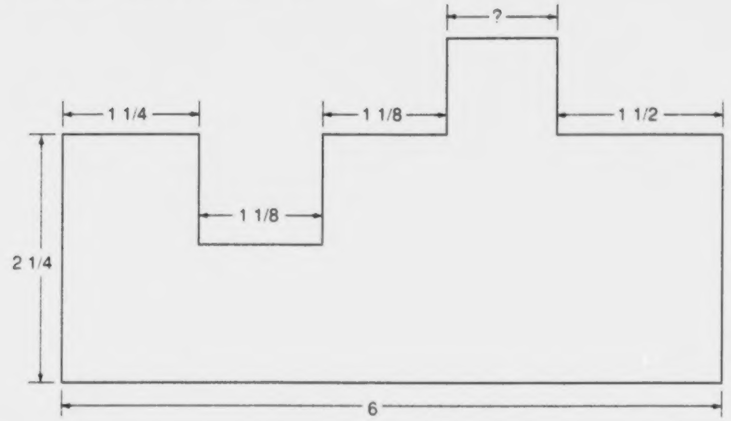
7. Methods of dimensioning

a. **Baseline or datum line** — A dimensioning method used when all dimensions on an object originate from a horizontal or vertical baseline or datum line



Information Sheet

b. **Conventional** — A method used when no set pattern is used for dimensioning and overall height, width, and length are usually given, but other dimensions may require addition or subtraction

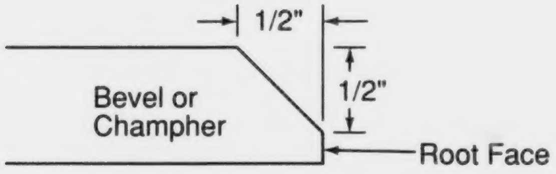

?
1 1/4
1 1/8
1 1/2
1 1/8
2 1/4
6

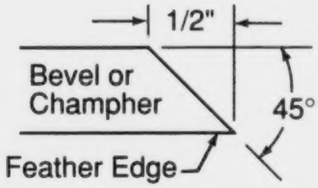
8. **Bevels and chamfers**

   a. A bevel is a sloping surface which extends the full or partial length of an edge.

   b. Chamfer is another term used for bevel, but chamber is normally used in machine shop practice while bevel is used in welding applications.

   Note: Dimensioning methods for bevels and chamfers are shown in the following graphic.


1/2"
1/2"
Bevel or Champher
Root Face

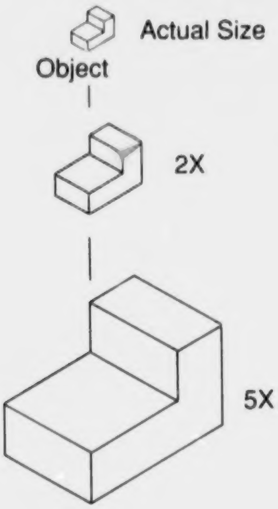

1/2"
Bevel or Champher
45°
Feather Edge

Information Sheet

9. Reduction and enlargement scales

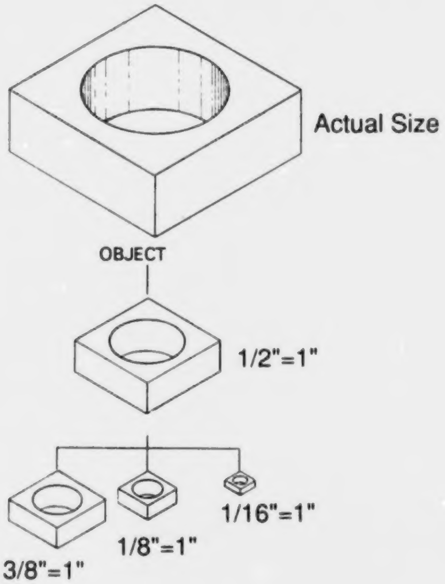
a. An enlargement scale presents an object larger than its actual size, usually twice as large, 2×, three times as large, 3×, 4×, 5×, and to the ratio required.

Example: 2″ = 1″
3″ = 1″
5″ = 1″


Actual Size
Object
2X
5X

b. A reduction scale presents an object smaller than its actual size, usually half-size, quarter size, and as needed with the ratio expressed in fractions and inches.

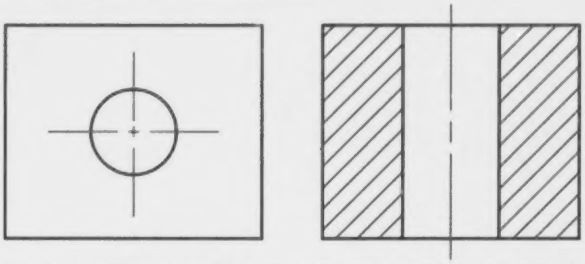
Example: ½″ = 1″
⅜″ = 1″
⅛″ = 1″
¹⁄₁₆″ = 1″


Actual Size
OBJECT
1/2"=1"
3/8"=1"
1/8"=1"
1/16"=1"

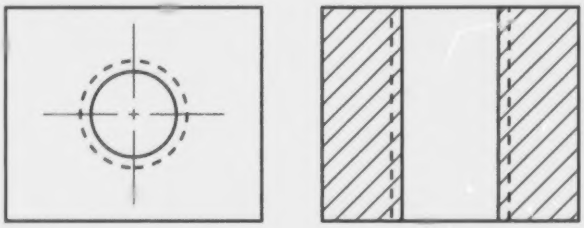
Information Sheet

10. Types of holes

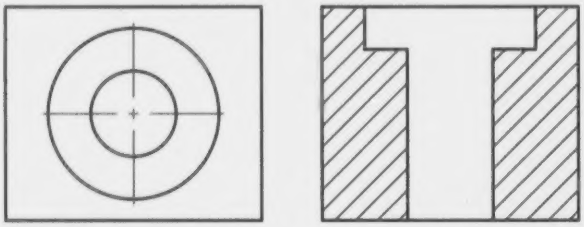
a. **Drilled** — A smooth sided hole that is made with a fractional size ($\frac{1}{16}$, $\frac{1}{8}$), letter size (F, E), or number size (6, 8, 12) drill bit; the hole is to go all the way through unless depth is dimensioned



b. **Threaded** — A hole drilled and then threads cut on the sides of the hole for the insertion of proper sized bolts



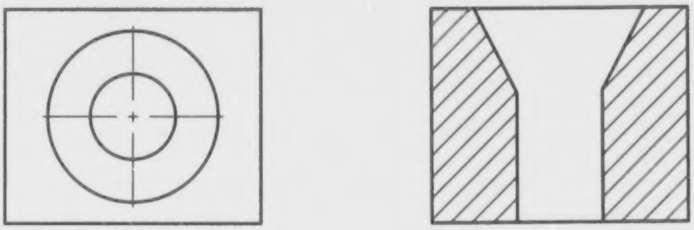
c. **Counterbore** — An hole enlarged to a certain size and depth for counterbore bolts to be recessed and provide a smooth top surface



Note: Dimension that must be applied to a counterbored hole include drill size for threaded hole, diameter or counterbore, and depth of counterbore.

Information Sheet

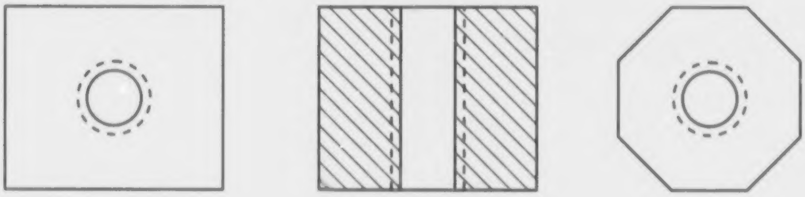
d. **Countersunk** — A hole enlarged with beveled edge angles to a certain degree and diameter in order to allow a countersunk bolt to be recessed and provide a smooth top surface



Note: The dimensions that must be applied to a countersunk hole include drill size for the threaded hole, diameter of the countersink, and degree of countersink.

11. **Threads**

a. Internal — Threads cut on the sides of a drilled hole or nut

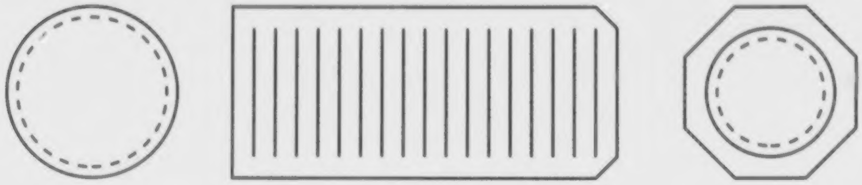


b. Information that must be applied to internal threads includes:

¾	10	UNC	3	A	L.H.
Diameter	Threads per inch	Tread series	Class of fit	Internal	If left handed

Information Sheet

c. External threads are cut on the outside of a bolt or screw.

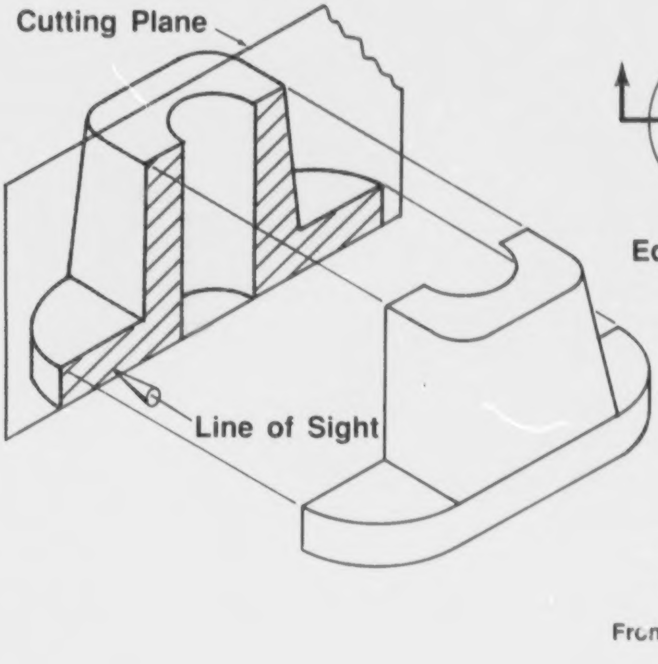


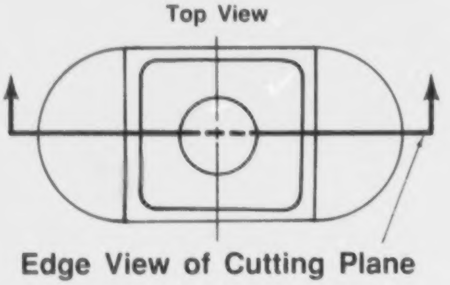
d. Information that must be applied to external threads includes:

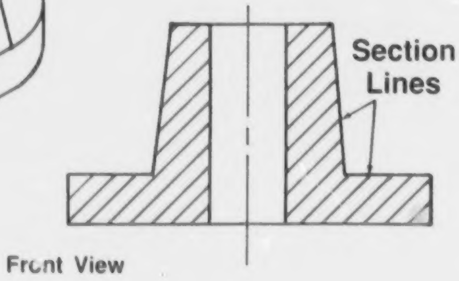
¾	10	UNC	3	B	
Diameter	Threads per inch	Tread series	Class of fit	External	If right hand thread this area is left blank

12. Types of section views

a. A full section view presents a cross section of an object so that it appears to have been cut entirely in half.

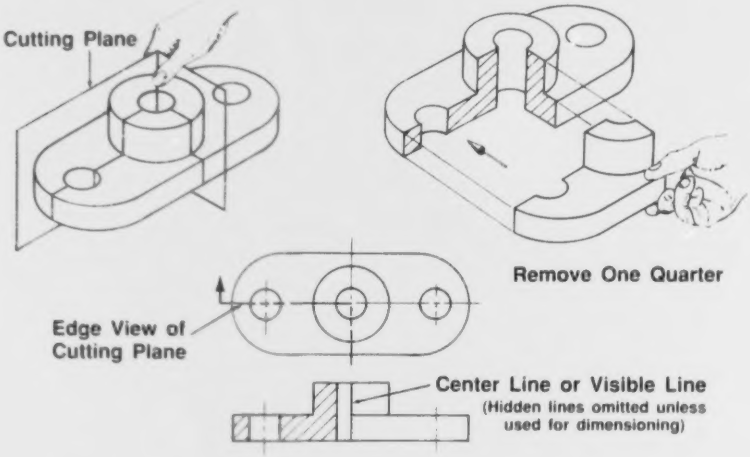

Cutting Plane
Line of Sight


Top View
Edge View of Cutting Plane

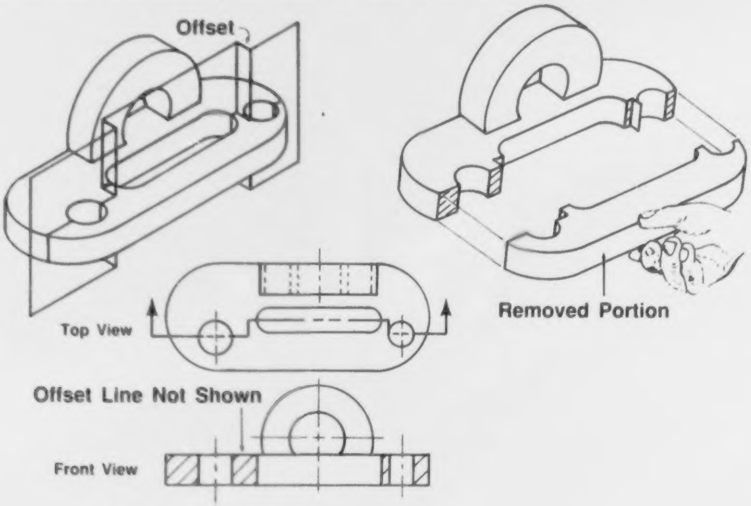

Section Lines
Front View

Information Sheet

b. A half section view presents a cross section of an object so that it appears to have had a quarter section cut out of it.

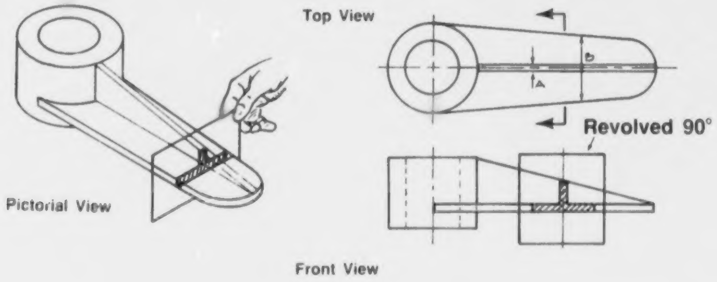

Cutting Plane
Remove One Quarter
Edge View of Cutting Plane
Center Line or Visible Line
(Hidden lines omitted unless used for dimensioning)

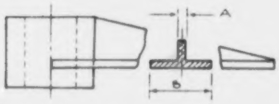
c. An offset section presents a cross section/view of an object so that it appears to have been cut entirely in half, but along an offset line.


Offset
Removed Portion
Top View
Offset Line Not Shown
Front View

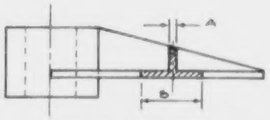
Information Sheet

d. A revolved section presents a cross section view of an object so that it appears to have been cut at a point and then rotated 90° so that shape and material composition can be shown.


Top View
Revolved 90°
Pictorial View
Front View
A
b



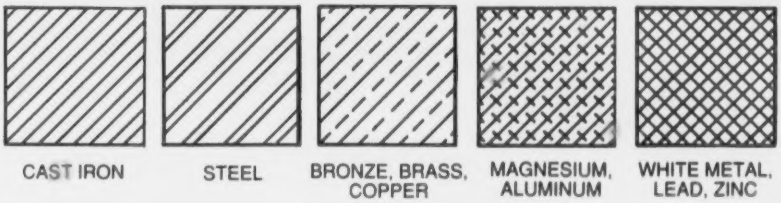
Broken Around Section

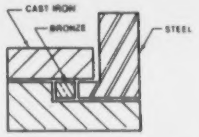


Section in View

13. Other symbols

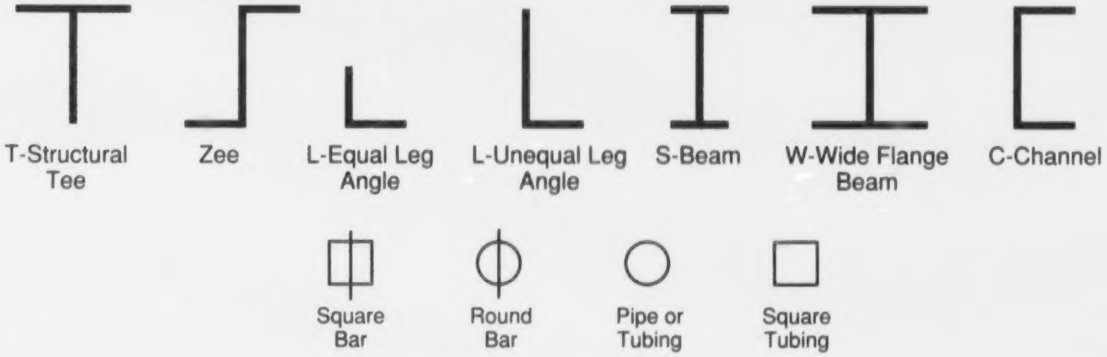
a. Material symbols use cross hatching lines to indicate composition of materials.


CAST IRON
STEEL
BRONZE, BRASS, COPPER
MAGNESIUM, ALUMINUM
WHITE METAL, LEAD, ZINC


CAST IRON
BRONZE
STEEL

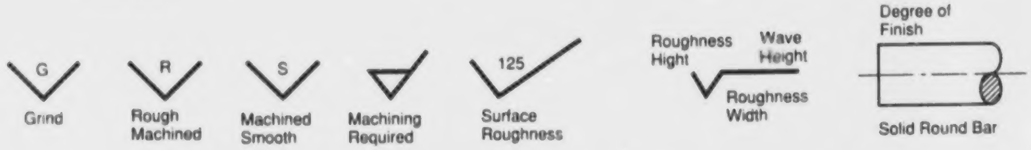
Different materials can be used to represent different parts in section

b. Stock components are depicted with lines that show their structural shapes.

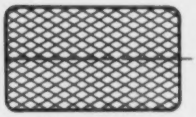

T-Structural Tee
Zee
L-Equal Leg Angle
L-Unequal Leg Angle
S-Beam
W-Wide Flange Beam
C-Channel
Square Bar
Round Bar
Pipe or Tubing
Square Tubing

Information Sheet

c. Machine symbols indicate to what degree of smoothness a surface should be finished.

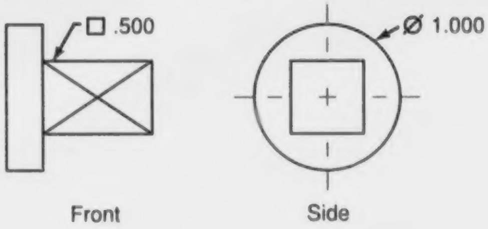

G
Grind
R
Rough Machined
S
Machined Smooth
Machining Required
125
Surface Roughness
Roughness Hight
Wave Height
Roughness Width
Degree of Finish
Solid Round Bar

d. A knurling symbol is used to indicate that a gripping surface should be provided on a normally smooth surface.



Knurling

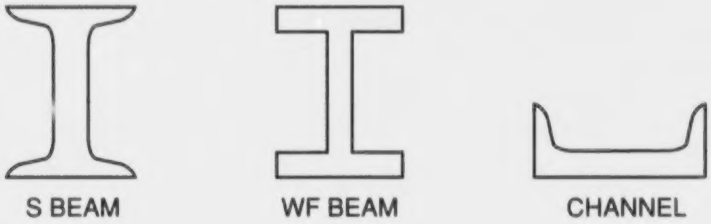
e. An X through a part indicates that an object is square when viewed from a side angle.


☐ .500
Ø 1.000
Front
Side

14. **Structural shapes**

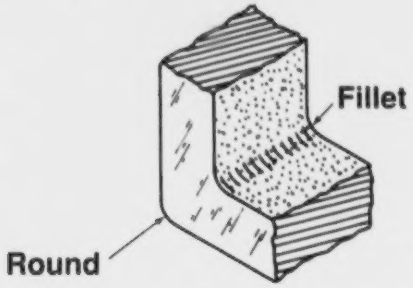
a. Many structural shapes are common to all varieties of structural fabrication.

b. The symbols for structural shapes are miniature pictorials of the shapes themselves.

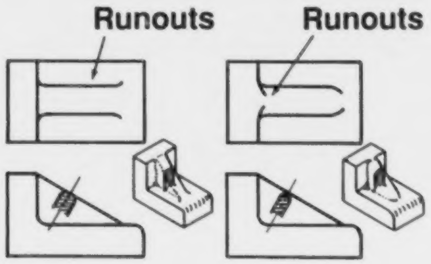

S BEAM
WF BEAM
CHANNEL

c. The fillet shape is an inside corner of a 90° angle whether machined smoothly or welded.

d. The round shape is an outside 90° corner.



e. A runout is a smooth continuation of a change in direction to avoid a weakened area that could result from an abrupt change.



15. **Requirements for a formal bill of material**

a. It should list the name of the firm that made the blueprint of drawing, the name of the firm for whom the drawing was made, and list the drafter's initials, date of drawing, and initials of the drafting supervisor who checked the print

b. It should list the part name last and items that define the part should precede the name.

Example: In the lower right hand of TM 1, the part is a Reflux Accumulator, and "from and to a depropanizer" indicates the specification position of the part in a flow line

c. It should detail parts by groups such as pipe, valves, flanges, and fittings, and all groups and parts should have mark numbers (MK) so they can be easily referred to in a numerical sequence

Information Sheet

d. It should specify quantities required, sizes required, and information relating specific grades, brand names, or standards to which the part must comply

e. It should clarify with notes important information taken directly from the blueprint for drawing, and related references to job number, location, and other materials necessary to properly relate the material list to the specific application that the print calls for

16. **Requirements for an informal bill of material**

a. It should arrange the materials in numerical order.

b. It should identify materials by a mark number (MK) in numerical sequence.

c. It should specify the number required for each part.

d. It should clearly define size or dimension of parts that require such information.

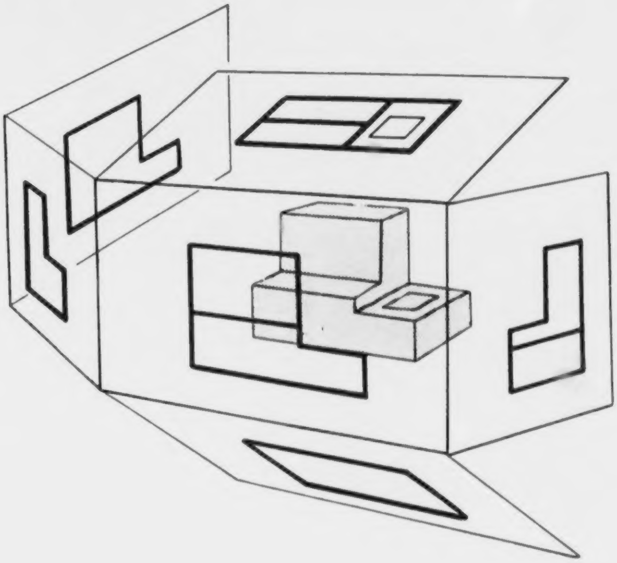
e. It should note any other information that helps to clarify quality of material or elements in the original print or drawing that should be referenced for better understanding of what the part or material is used for.

Welding Print Reading
Unit 6

Student Supplement 1—Orthographic Projection

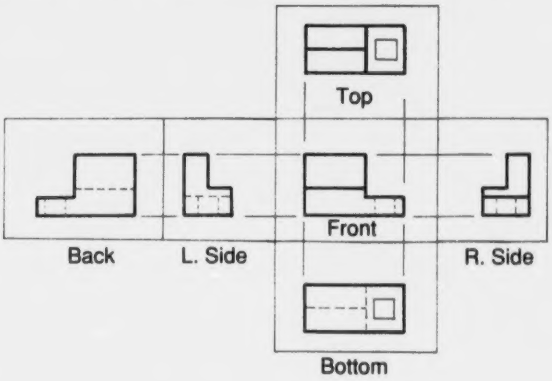
Basis

In an orthographic projection, all planes revolve until they align with a frontal plane which is referred to as the front view.



Managing orthographic views

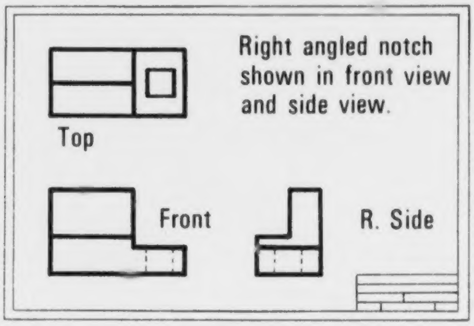
Orthographic views align with the frontal plane of an object, but can provide a view of an object from the top, front, right side, left side, bottom, and back



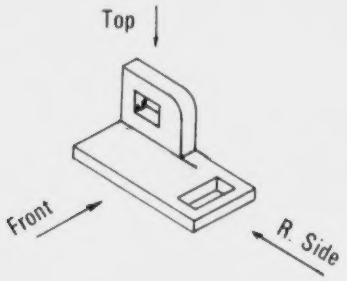
Student Supplement 1

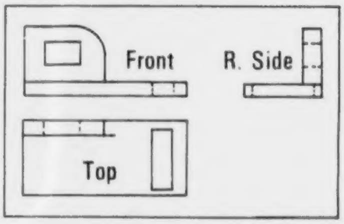
Principal views and positioning

The front, top, and side views are the principal views used in orthographic projections.

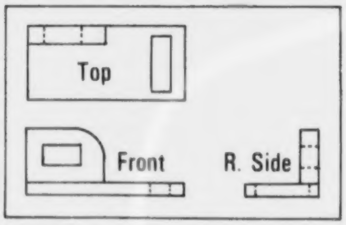

Right angled notch shown in front view and side view.
Top
Front
R. Side

In presentation, the top view should be above and aligned with the front view and the side view should also be aligned with the front view.

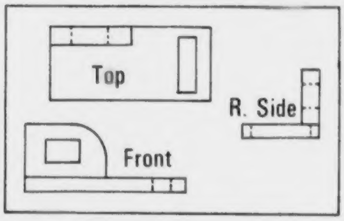

Top
Front
R. Side


Front
R. Side
Top

INCORRECT — Top Should Be Above Front


Top
Front
R. Side

CORRECT

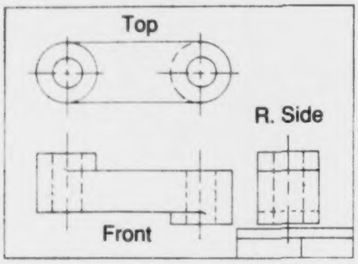

Top
R. Side
Front

INCORRECT — Views Not Lined Up

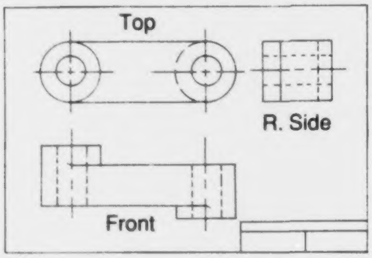
Student Supplement 1

Positioning the side view

As previously shown, the normal location of the side view is projected off the front view, but alternate positioning is acceptable when space in the normal location is occupied. In such a situation, the side view should be aligned with the top view as an alternated location.



Normal Location



Alternate Location

Significance

In general, pictorials make objects on a flat surface easier to visualize. Orthographic projections not only help with the visualization, but project details that relate planes of an object to its entire shape. In turn, this provides more accurate reference in fabrication of complex products.

Welding Print Reading
Unit 6

Student Supplement 2—Common Abbreviations and Their Meanings

AISI — American Iron and Steel Institute

ANSI — American National Standards Institute

ASME — American Society of Mechanical Engineers

ASTM — American Society for Testing and Materials

AWG — American Wire Gage

AWS — American Welding Society

ASSY — Assembly

BC — Bolt Circle

BEV — Bevel

B/M — Bill of material

BWG — Birmingham Wire Gage

B&S — Browne & Sharpe Wire Gage

BRS # — Brass, SAE #

BRZ # — Bronze, SAE #

C TO C — Center to center

CBORE — Counterbore

CDRILL — Counterdrill

CHAM — Chamfer

CI — Cast iron

CL ℄ — Center line

CRS — Cold rolled steel

CS — Cast steel

CSK — Countersink

DEG or ° — Degree(s)

DIA or ∅ — Diameter

DIM — Dimension

DWG — Drawing

FAB — Fabricate

FAO — Finish all over

FT or ′ — Foot, feet

GA — Gage or gauge

HRS — Hot rolled steel

ID — Inside diameter

In or ″ — Inch, inches

KWY — Keyway

LB or # — Pound, pounds

LH — Left hand

MATL — Material

MI — Malleable iron

MIL-STD — Military standard

Student Supplement 2

MIN or ′ — Minute, minutes

mm — Millimeter

MS — Mild steel

NDT — Nondestructive testing

NO # — Number

NTS — Not to scale

OC — On center

OD — Outside diameter

P — Pitch

PC — Piece, pieces

PL — Plate

PSI — Pounds per square inch

RAD — Radius

REF L — Reference line

REQD — Required

RD — Round

RPM — Revolutions per minute

S — S beam

SAE — Society of Automotive Engineers

SCH — Schedule

SQ FT — Square foot, feet

SQ IN — Square inch, inches

SQ or □ — Square

SST — Stainless steel

STD — Standard

STL — Steel

TYP — Typical

V — Volt

VOL — Volume

W — Watt

WT — Weight

WI — Wrought iron

YD — Yard, hards

X, × — Multiply by, times, places

Welding Print Reading
Unit 6

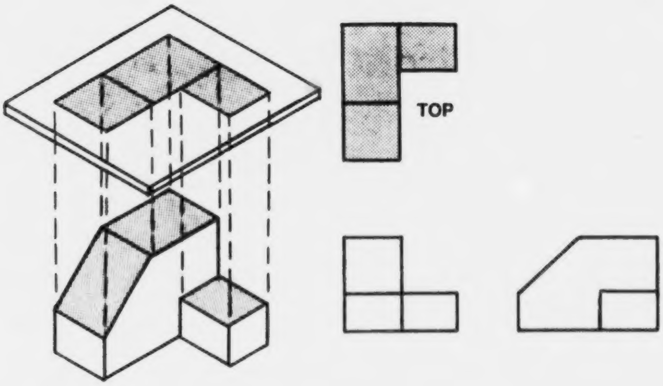
Assignment Sheet 1—Construct a Top View

Name ______________________________ Overall Rating __________

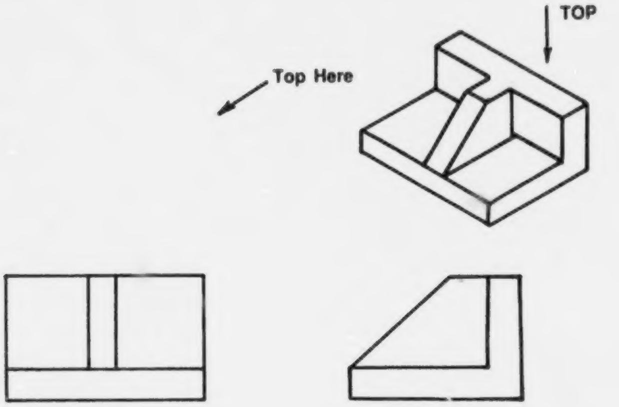
Evaluation criteria	**Rating**
Proper construction of top views	______
Number of constructions completed	______

Directions: Study the example carefully and use it as a guide for constructing the top views that follow. Be sure to align views properly so that you can transfer lines.

Example:

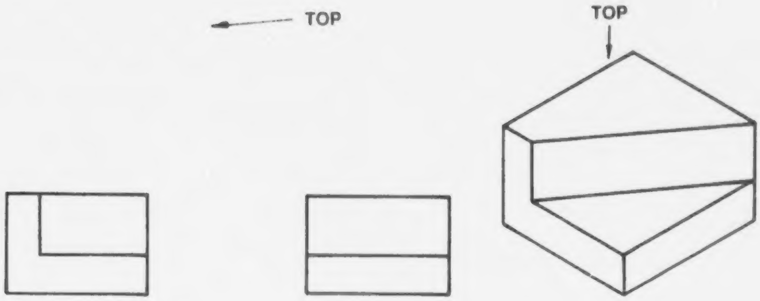


Problem 1:

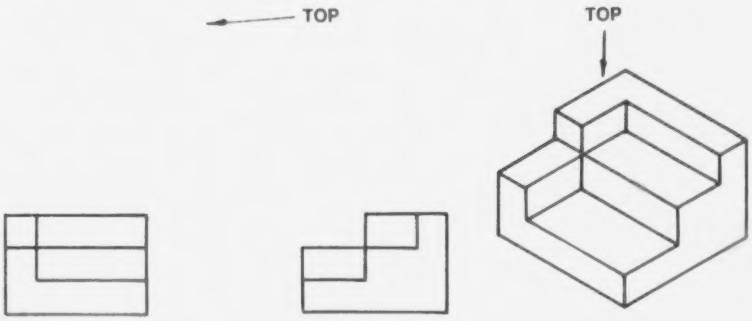


Assignment Sheet 1

Problem 2:

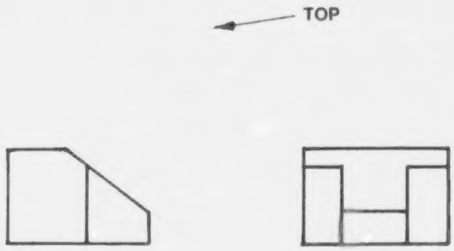


Problem 3:



Assignment Sheet 1

Problem 4:



Welding Print Reading
Unit 6

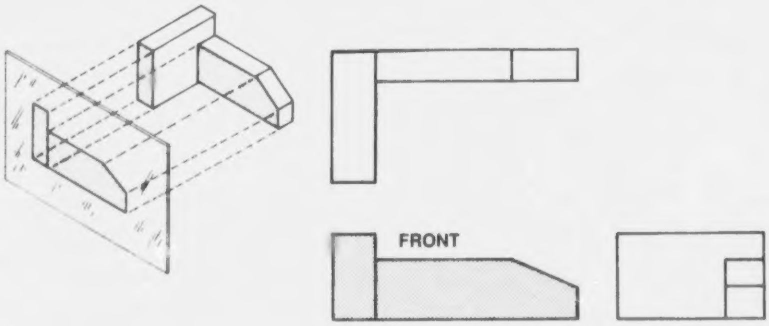
Assignment Sheet 2—Construct a Front View

Name ______________________________ Overall Rating __________

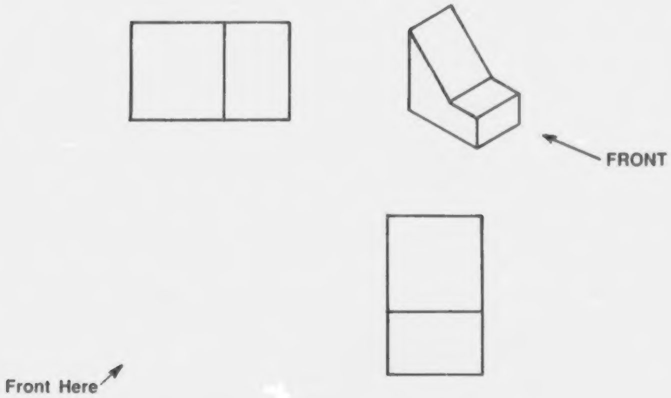
Evaluation criteria	**Rating**
Proper construction of front views	______
Number of constructions completed	______

Directions: Study the example carefully and use it as a guide for constructing the front views that follow. Be sure to align views properly so that you can transfer lines.

Example:

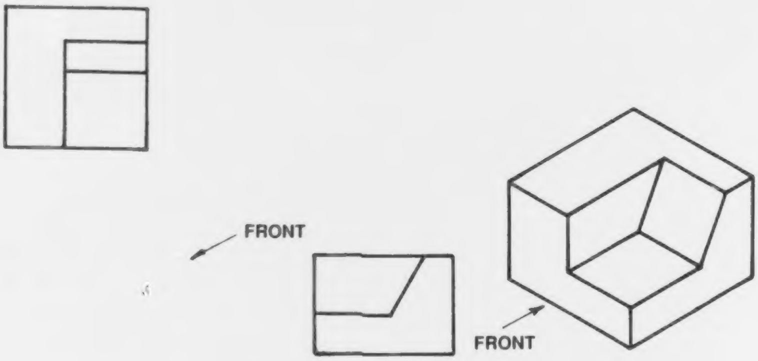


Problem 1:

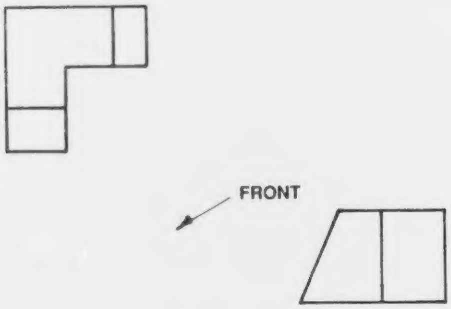


Assignment Sheet 2

Problem 2:


FRONT
FRONT

Problem 3:



Welding Print Reading
Unit 6

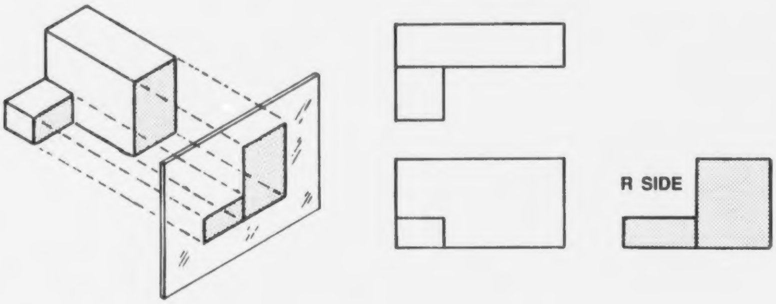
Assignment Sheet 3—Construct a Right Side View

Name ______________________________ Overall Rating __________

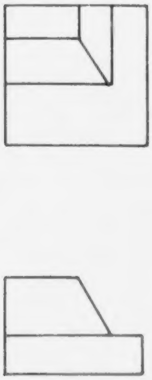
Evaluation criteria	**Rating**
Proper construction of side views	______
Number of constructions completed	______

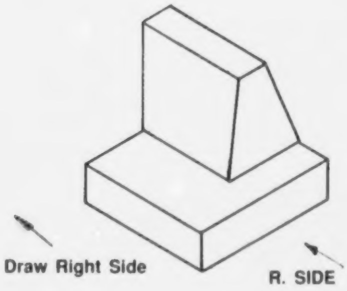
Directions: Study the example carefully and use it as a guide for constructing the right side views that follow. Be sure to align views properly so that you can transfer lines.

Example:



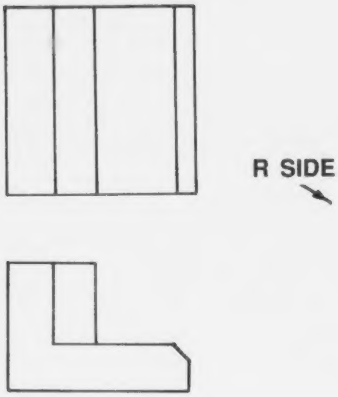
Problem 1:

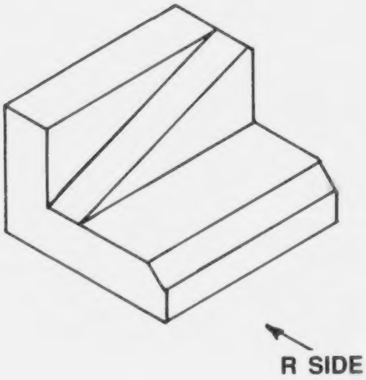




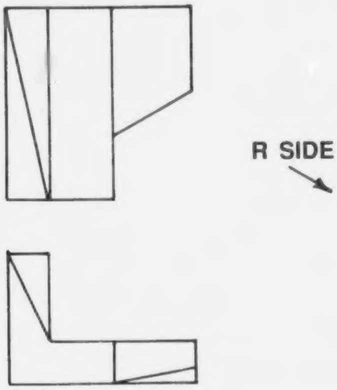
Assignment Sheet 3

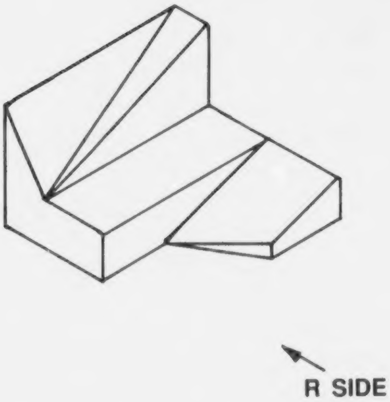
Problem 2:



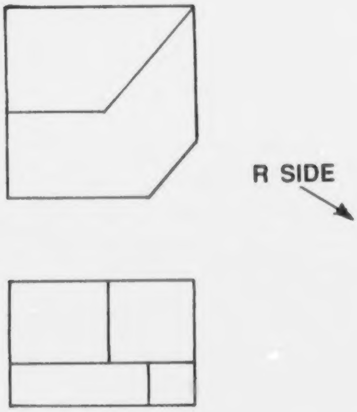


Problem 3:





Problem 4:



Welding Print Reading
Unit 6

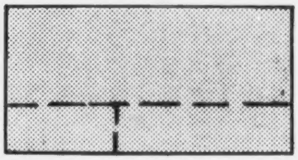
Assignment Sheet 4—Construct Missing Hidden Lines

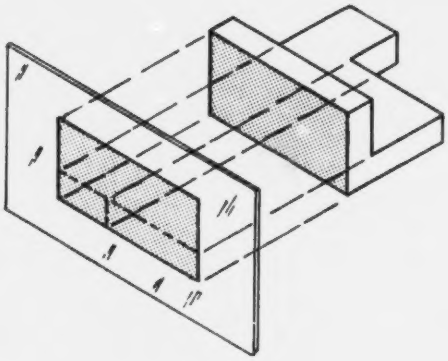
Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Proper construction of hidden lines	______
Number of constructions completed	______

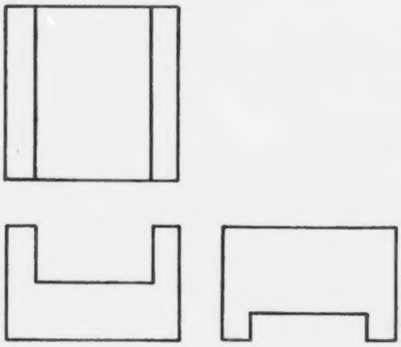
Directions: Study the example carefully and use it as a guide for constructing the missing hidden lines that follow. Be sure to align views properly so that you can transfer lines.

Example:



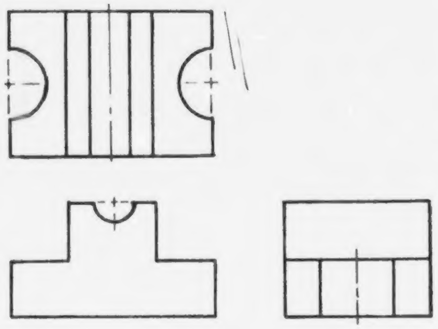


Problem 1:

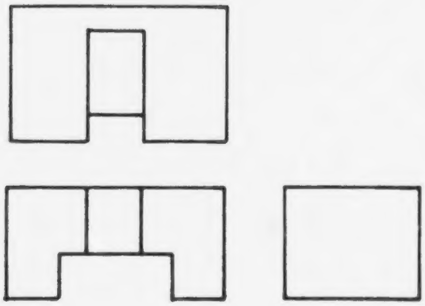


Assignment Sheet 4

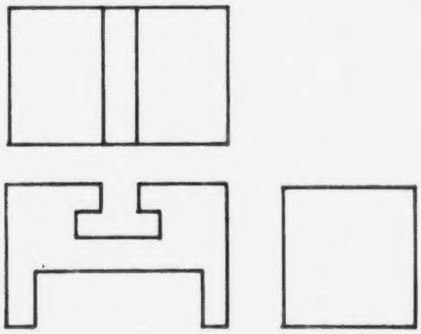
Problem 2:



Problem 3:



Problem 4:



Welding Print Reading
Unit 6

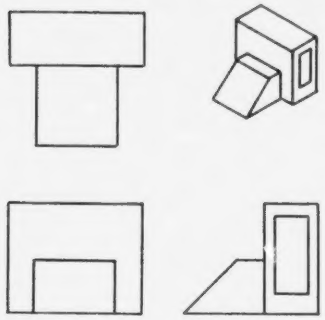
Assignment Sheet 5—Construct Missing Visible and Hidden Lines

Name ______________________________ Overall Rating __________

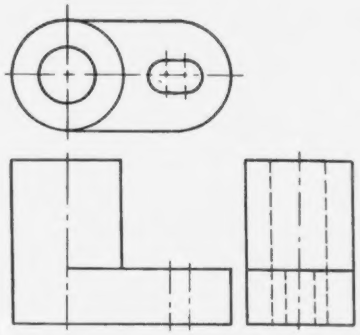
Evaluation criteria	**Rating**
Proper construction of visible and hidden lines	______
Number of constructions completed	______

Directions: Study the example carefully and use it as a guide for constructing the missing visible and hidden lines that follow. Keep views aligned or tape down as needed.

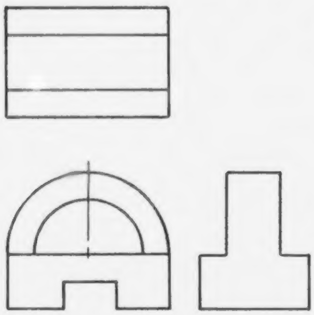
Problem 1:



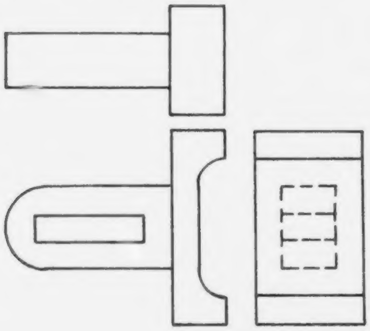
Problem 2:



Problem 3:

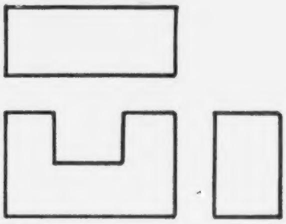


Problem 4:

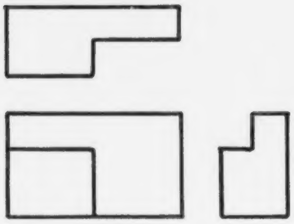


Assignment Sheet 5

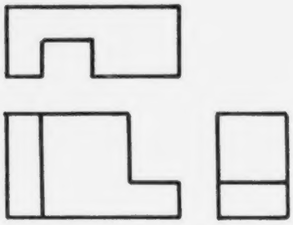
Problem 5:



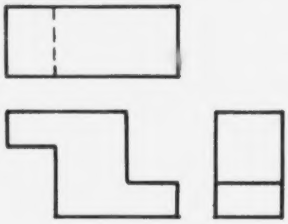
Problem 6:



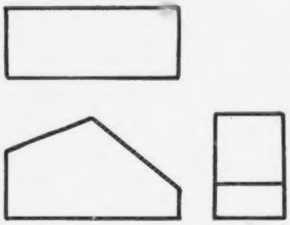
Problem 7:



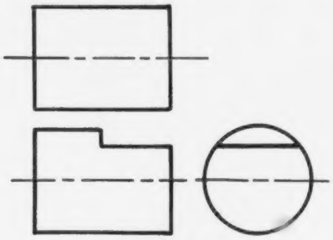
Problem 8:



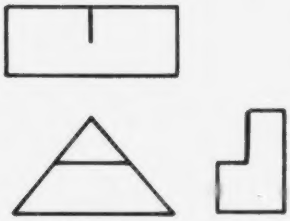
Problem 9:



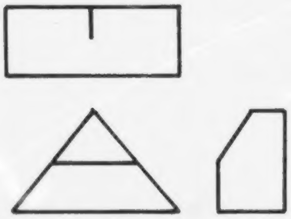
Problem 10:



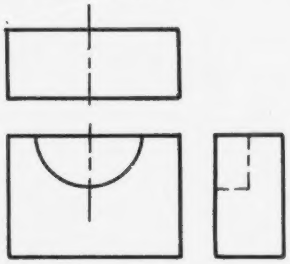
Problem 11:



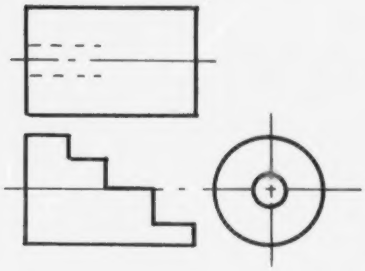
Problem 12:



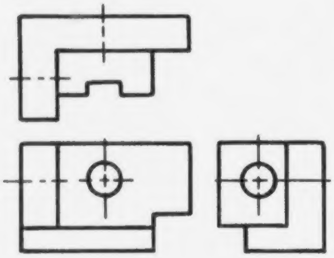
Problem 13:



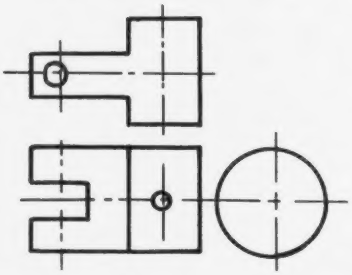
Problem 14:



Problem 15:



Problem 16:



Welding Print Reading
Unit 6

Assignment Sheet 6—Make a Three-View Sketch

Name ______________________________ Overall Rating ____________

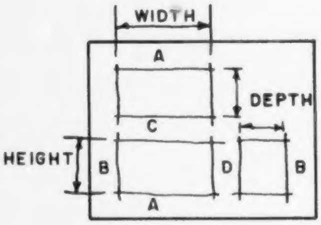
Evaluation criteria	**Rating**
Proper construction lines	______
Presentation of details	______
Final presentation	______

Directions: Study the example given and then complete the following problem.

Example:

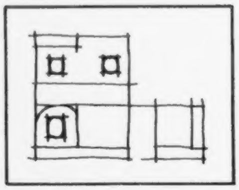
1. Sketch the horizontal lines to locate the height of the object.

   Note: The distance at the top and bottom of the paper should be the same. The distance between the top and front views can be the same as that on the top and bottom or slightly less than that space.

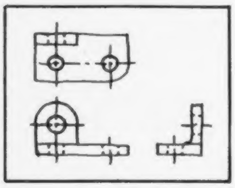


2. Sketch the vertical lines to locate the width and depth of the object.

   Note: The distance at the left side and right side of the paper should be the same. The distance between the views can be the same as that on the left side and right side or slightly less than that space. In the top and side views, the depth must be equal; this can be done by marking a piece of paper with depth.



3. Block in details using diagonals to locate centers, if necessary, and lightly sketch the circles and arcs.

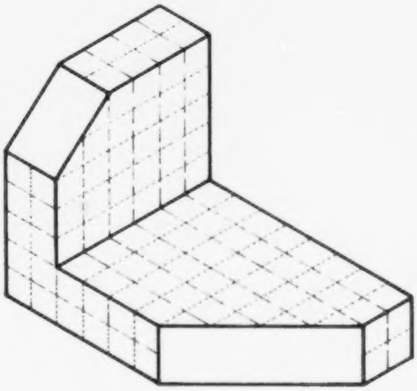


4. Add line features to the views of the object.

5. Use an artgum eraser to dim construction lines and darken in visible lines.

Assignment Sheet 6

Problem: Sketch three views of the object below using the grid provided for measurements or gridded drawing media if requested by instructor.



Welding Print Reading
Unit 6

Assignment Sheet 7—Construct Adjacent Parts in an Assembly Section

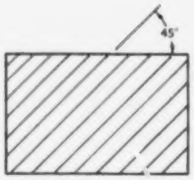
Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Lines drawn at proper degrees	______
Proper material presentation	______

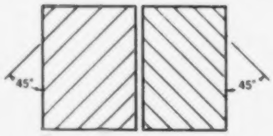
Directions: Study the example carefully and use is as a guideline to complete the assemblies in the following problems.

Example:

1. The first section lines are constructed at an angle of 45° to the main outline of the object.

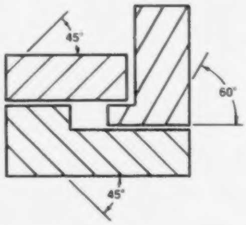


2. On adjacent parts, section lines should be 45° in the opposite direction.

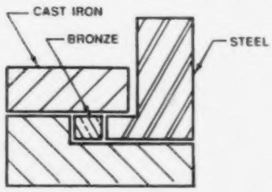


3. For more than two parts adjacent to each other, section lines should be drawn at an angle of 30° or 60°.

   Note: Section lines should not be drawn to meet a common lines.



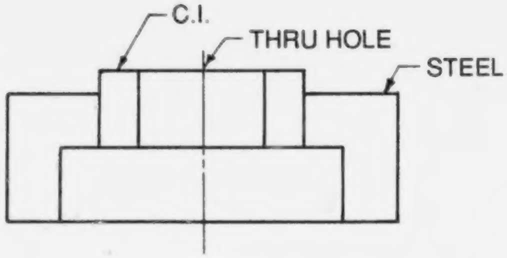
4. Different materials can be used to represent different parts in section.



Assignment Sheet 7

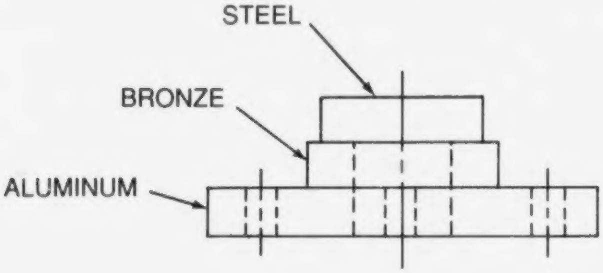
Directions: Complete this assembly as a section using the proper symbols. Refer to the items in the Information Sheet if you need to.

Problem A


C.I.
THRU HOLE
STEEL

Directions: Complete front view using the symbols called for. Refer to items in the Information Sheet if you need to.

Problem B:


STEEL
BRONZE
ALUMINUM

Welding Print Reading
Unit 6

Assignment Sheet 8—Interpret Tolerance Dimensions

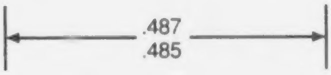
Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
Expression of decimal tolerances	______
Expression of fractional tolerances	______
Expression of degree tolerances	______

Directions: Study the example or expressing tolerances in decimals, fractions, and degrees. Use the examples as guidelines to complete the tolerance problems that follow.

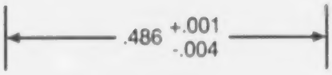
Examples:

1.



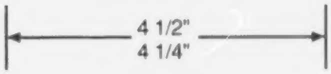
.487 Maximum limit
.485 Minimum limit
.002 Total tolerance

2.



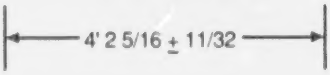
.487 Maximum limit
.482 Minimum limit
.005 Total tolerance

3.



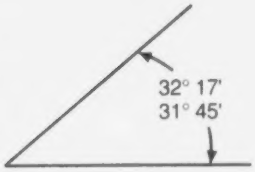
4½ Maximum limit
4¼ Minimum limit
¼ Total tolerance

4.



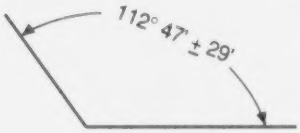
4′ 2 21/32″ Maximum limit
4′ 1 31/32″ Minimum limit
22/32″ Total tolerance

5.



32° 17′ Maximum limit
31° 45′ Minimum limit
32′ Total tolerance

6.

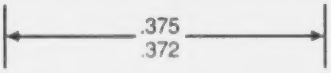


113° 16′ Maximum limit
112° 18′ Minimum limit
58′ Total tolerance

Assignment Sheet 8

Directions: Determine decimal tolerance dimensions for the following problems.

Problem 1:

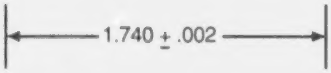


Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Problem 2:

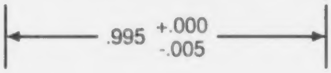


Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Problem 3:



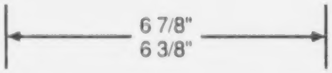
Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Directions: Determine fractional tolerance dimensions for the following problems.

Problem 4:



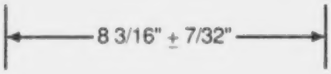
Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Assignment Sheet 8

Problem 5:

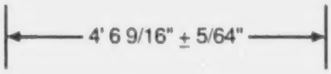


Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Problem 6:



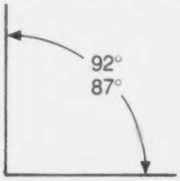
Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Directions: Determine degree tolerance dimensions for the following problems.

Problem 7:

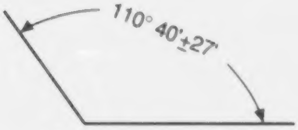


Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Problem 8:



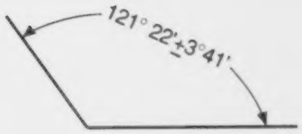
Maximum limit = ____________________

Minimum limit = ____________________

Total tolerance = ____________________

Assignment Sheet 8

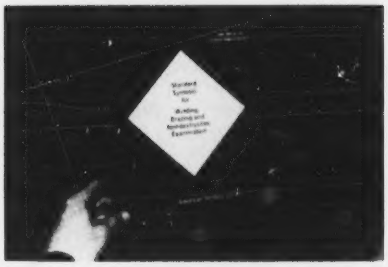
Problem 9:



Maximum limit = ______________________________

Minimum limit = ______________________________

Total tolerance = ______________________________



Basic Welding Joints and Symbols
Unit 7

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify basic welding symbols, interpret basic welding symbols, interpret working welding symbols, draw welding symbols for given specifications, and interpret a welding print and welding procedure specifications. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the students should be able to:

1. Match terms related to basic welding joints and symbols with their correct definitions.
2. Complete statements about basic parts of a welding symbol.
3. Complete statements about arrow side, other side significance.
4. Select true statements about arrow line variations.
5. Differentiate between weld symbols and welding symbols.
6. Identify supplementary symbols.
7. Identify contour and finish symbols.
8. Interpret information in a welding symbol tail.
9. Identify basic welding joints.
10. Interpret basic welding symbols.
11. Apply basic rules for locating dimensions.
12. Apply additional symbols to fillet welds.
13. Interpret nondestructive testing symbols.

Objective Sheet

14. Select true statements about procedures for fitting up and welding structural shapes.

15. Identify basic weld symbols. (Assignment Sheet 1)

16. Interpret basic welding symbols. (Assignment Sheet 2)

17. Interpret working welding symbols. (Assignment Sheet 3)

18. Draw welding symbols for given specifications. (Assignment Sheet 4)

19. Interpret a welding print and welding procedure specifications. (Assignment Sheet 5)

Basic Welding Joints and Symbols
Unit 7

Suggested Activities

Instructional Plan

Preparation

1. Read the unit carefully and plan for instruction.

2. Review Teaching Suggestions that follow. Plan for classroom activities.

3. Plan presentation for enrichment of exceptional students as well as accommodation of special needs students.

4. Make transparencies from the transparency masters included with this unit. These appear in the teacher edition only and are designed to be used with the following objectives:

   TM 1—Welding Angle to Angle (Objective 14)
   TM 2—Welding Angle to Channel (Objective 14)
   TM 3—Welding Channel to Channel (Objective 14)
   TM 4—Welding Channel to S or W Beams (Objective 14)
   TM 5—Welding S Beams to W or W to S Beams (Objective 14)
   TM 6—Welding Angle to S or W Beams (Objective 14)

5. Obtain films, videotapes, and other resources to supplement instruction of this unit. See ordering information in the Suggested Supplemental Resources that follow.

6. Develop a teaching plan. Adjust for different learning styles.

7. Make copies of Unit Evaluation Form.

Delivery and Application

8. Provide students with unit of instruction.

9. Discuss unit and specific objectives.

10. Discuss information sheet. Implement teaching plan to localize, supplement,a nd personalize the unit. Reinforce basic skills when applicable.

11. Discuss assignment sheets. Review criteria for evaluation of these activities.

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Suggested Activities

Evaluation

12. Discuss the use of the Unit Evaluation Form with students. Discuss the rating scale that will be used for student evaluation.

13. Make copies of the written test. Add or modify test questions as needed.

14. Give written test.

15. Compile assignment sheet ratings and written test scores on the Unit Evaluation Form. Include any additional assignments.

16. Reteach and retest as required.

Teaching Suggestions

Note: Skill areas appearing in boldface type in the Teaching Suggestions refer to the academic and workplace skills identified by the American Society for Training and Development (ASTD) and the U.S. Department of Labor. These ASTD skill areas have been adapted by MAVCC.

1. Place special emphasis on Objectives 1, 2, and 3 as you present this unit. The referenced objectives cover the basics of weld and welding symbols along with the terminology required to understand symbol applications. Skill area: **learning to learn**.

2. Stress the difference between a weld symbol and a welding symbol as they are illustrated in Objective 5. Make sure students understand and appreciate the difference between the two. Skill area: **learning to learn**.

3. As you teach Objective 6 and the objectives that follow, have students begin sketching welding symbols and the supplementary symbols that go with them. This will prepare them to better handle the assignment sheets that conclude the unit. Skill areas: **foundation skills** and **science**.

4. When you teach dimensioning symbols, have students measure and write dimensioning information for workpieces they have completed themselves. Pay particular attention to the dimensioning of fillet welds. Skill areas: **foundation skills** and **math**.

5. The weld symbols, names, and definitions included in the extensive list in Student Supplement 1 are designed not only for reference, they can be used for chalkboard tests. Put a symbol a day on the chalkboard and have students reference Supplement 1 until they can identify symbols, or relate symbols to definitions without using the supplement. Skill areas: **learning to learn**.

Suggested Activities

Resources Used in Developing This Unit

1. *Standard Symbols for Welding, Brazing, and Nondestructive Testing*, ANSI/AWS A2.4-86. Miami, FL: American Welding Society, 1986.

2. *Standard Welding Terms and Definitions*, ANSI/AWS A3.0-89. Miami, FL: American Welding Society, 1989.

3. *Standard for Welding Procedure and Performance Qualification*, AWS B2.1-84. Miami, FL: American Welding Society. 1987.

4. Connor, Leonard P., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Technology*. Miami, FL: American Welding Society, 1987.

5. O'Brien, R. L., ed. *Welding Handbook, Eighth Edition, Vol. 1, Welding Processes*. Miami, FL: American Welding Society, 1991.

Suggested Supplemental Resources

1. *Blueprint Reading for Welders, Fourth Edition*. This text by Frank Schell and Bill Matcock was published by Delmar Publishers in 1988. It has been updated to bring it into agreement with AWS welding symbols, and a new section on stud welding has been added. The section on inspection and testing has also been expanded.

2. *Symbols for Welding* is a new video by the American Welding Society. The video clearly explains how to differentiate the many commonly used welding symbols for fillet welds, groove welds, slot welds, plug welds, and many others. It is designed to increase the ability to read symbols and to improve welding efficiency. The purchase price includes a free copy of a training manual for the program. A test with questions and answers is also included in the package. The code for the video is SW and is available from:

   Order Department
   American Welding Society
   550 Northwest LeJeune Road
   P.O. Box 351040
   Miami, FL 33135
   800-334-9535 (Orders only)
   800-443-9353 (Information)
   305-443-7559 (FAX)

Basic Welding Joints and Symbols
Unit 7

Answers to Assignment Sheets

Assignment Sheet 1

1. Melt through
2. U-groove
3. Surfacing
4. Spot or projection
5. Staggered intermittent fillet
6. V-groove
7. Square groove
8. Penetrant test, 8″ long
9. Backing removed
10. Seam weld
11. Fillet weld
12. Square groove with ⅛″ root opening
13. J-groove
14. Back or backing
15. Bevel groove

Assignment Sheet 2

1. a. Tail
   b. Other side
   c. Arrow side
   d. Reference line
   e. Arrow line

2. a. Depth
   b. Broken arrow
   c. Bevel groove
   d. Back or backing weld
   e. See note

3. a. Leg size
   b. Length
   c. Pitch
   d. Flush
   e. Machine
   f. Field weld
   g. Fillet weld

Answers to Assignment Sheets

4. a. Depth
    b. Weld size
    c. J-groove
    d. Fillet weld
    e. Root opening
    f. Included angle
    g. Unequal leg
    h. Specification
    i. Weld all around

5. a. Diameter
    b. Plug weld
    c. Depth of fill
    d. Pitch
    e. Included angle
    f. Gas Metal Arc Welding

Assignment Sheet 3—Order may vary, but student answers should contain all of the following:

1. Staggered, intermittent fillet weld.
   Arrow side is ⅜″ fillet, 2″ length, 8″ pitch.
   Other side is ½″ fillet, 2″ length, 8″ pitch.
   Weld all around. See Spec. E-2.

2. Arrow side ½ deep V-groove with ⅛″ root opening.
   65° included angle ground flush.
   Other side, 1⁄16″ back weld.

3. Arrow side ¼″ deep bevel groove with 30° included angle.
   Unequal leg fillet added, see detail A.
   Broken arrow. Other side, ⅜″ deep bevel groove with 45° included angle with ¼″ fillet added.

4. Arrow side, ¼″ deep bevel groove with 25° included angle.
   Chipped flush, welded in the field, broken arrow.
   Other side, ⅛″ melt through, machined convex.

5. Arrow side, 3⁄16″ fillet weld, weld all around.
   Other side, ⅜″ fillet weld
   Use gas tungsten arc welding.

6. Arrow side 1⅜″ diameter plug weld, 6″ pitch.
   60° included angle, machine flush.

Answers to Assignment Sheets

7. Arrow side, V-groove with 1/4" root opening.
   Other side, backing removed, machine flush, see Note 2.
   Ultrasonic test other side.

8. Other side, 3/16" deep J-groove with 1/16" root opening.
   20° included angle, machine convex.
   Arrow side, melt through, grind flush. Use gas metal arc welding, broken arrow.

9. Both sides, square groove with 1/8" root opening, welded all around in the field.

10. Arrow side, 1/2" deep U-groove with 0 (zero) root opening, 65° included angle.
    Other side, 3/8" deep U-groove with 0 (zero) root opening, 65° included angle.

11. Arrow side, 3/16" diameter resistance projection weld, 10" pitch, 12 of them.

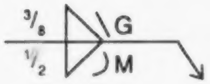
12. Arrow side, slot weld, see Detail A, depth of fill 1/2".

13. Arrow side, 5/16" deep bevel groove with 1/8" root opening, 60° included angle, broken arrow.
    Other side, square groove with 1/8" root opening, 3/8" weld size.

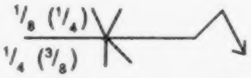
14. Arrow side, 3/8" deep V-groove, 1/2" weld size with 1/4" root opening, 45° included angle, 1/2 weld size, ground flush.
    Other side, back gouge, back weld, ground flush.
    Arrow side, radiographic testing.

Assignment Sheet 4

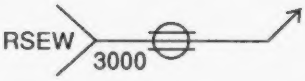
1.



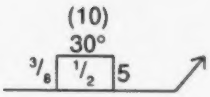
2.



3.

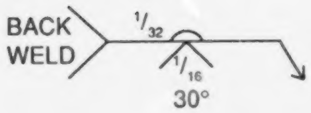


4.

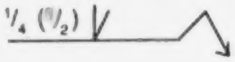


Answers to Assignment Sheets

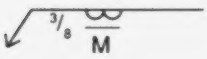
5.


BACK
WELD
1/32
1/16
30°

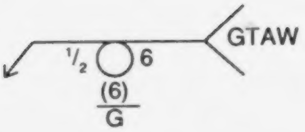
6.



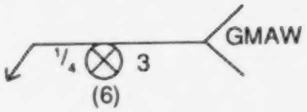
7.



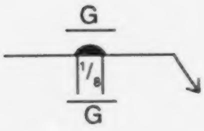
8.



9.



10.



Assignment Sheet 5

1. c
2. b
3. c
4. a
5. d
6. b
7. a
8. c
9. d
10. b

Basic Welding Joints and Symbols
Unit 7

Answers to Written Test

1. a. 3
   b. 5
   c. 4
   d. 1
   e. 2
   f. 7
   g. 6
   h. 8
   i. 9

2. a. Above, below, or on
   b. Closest the arrow
   c. Either end
   d. In any direction
   e. The end of
   f. The tail is not used

3. a. On the same side the arrow points to
   b. On the opposite side the arrow points to

4. Both a and b are false

5. b

6. a. 3
   b. 6
   c. 2
   d. 5
   e. 1
   f. 4

7. a. 4
   b. 5
   c. 1
   d. 2

8. Answers should approximate those given:

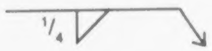
   a. Calls for complete joint penetration of the weld
   b. Calls for gas metal arc welding process

9. a. 3
   b. 5
   c. 1
   d. 2
   e. 4

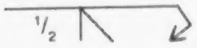
Answers to Written Test

10. a. Fillet, other side
    b. V-groove, both sides
    c. Bevel groove, arrow side, broken arrow
    d. Square groove, other side
    e. J-groove, arrow side, broken arrow
    f. U-groove, both sides
    g. Flare V, arrow side
    h. Flare bevel, other side, broken arrow
    i. Plug or slot, arrow side
    j. Stud, arrow side
    k. Spot, no arrow or other side significance
    l. Projection, or spot, arrow side
    m. V-groove with back or backing, arrow side
    n. Surfacing, arrow side
    o. Seam, arrow side
    p. Edge flange, other side
    q. Corner flange, arrow side, broken arrow

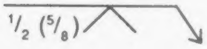
11. a.



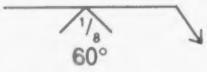
b.



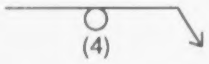
c.



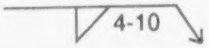
d.



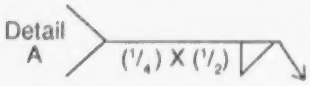
e.

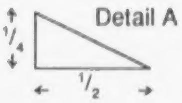


f.



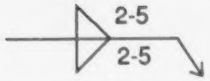
12. a.



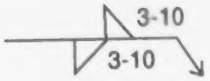


Answers to Written Test

b.



c.



13. a. 2
    b. 3
    c. 3

14. a, c

Basic Welding Joints and Symbols
Unit 7

Written Test

Name ______________________________ Score ______________

1. Match the terms on the right with their correct definitions.

_______a. Rounded or curved inward in relation to adjoining planes

_______b. Preplaced filler metal that is completely fused into the joint root and becomes part of the weld

_______c. Rounded or curved outward in relation to adjoining planes

_______d. Forming a relatively level or continuous plane on a surface

_______e. The part that is welded, brazed, soldered, thermal cut, or thermal sprayed

_______f. The beveled edges of workpieces made by cutting two pieces at angles and joining them

_______g. The center-to-center distance between two welds

_______h. A graphical representation indicating the type of weld required

_______i. A graphical representation of a weld symbol and other elements applied in standardized notation

1. Flush
2. Workpiece
3. Concave
4. Convex
5. Consumable insert
6. Pitch
7. Miter
8. Weld symbol
9. Welding symbol

Written Test

2. Complete statements about basic parts of a welding symbol. Circle the information that best completes each statement.

   a. A reference line is a straight line on a horizontal plane with all other welding information located (**above or below**) (**above, below, or on**) the reference line.

   b. Multiple reference lines are used to indicate a sequence of welds or associated activity with the first weld of the series (**closest the arrow**) (**on the top line**).

   c. An arrow line extends at an angle from (**either end**) (**the left end**) of a reference line and is terminated with an arrowhead.

   d. The arrow may point (**in any direction**) (**in only one direction**), but it always points to the welding joint which requires preparation and/or welding.

   e. The tail of a welding symbol is at (**the end of**) (**a selected point on**) a reference line, opposite the arrow and it has the horizontal V-shape of feathers at the end of an arrow.

   f. The free space in the tail is used for notes, specifications, process, and other items, but if no instructions are required, (**the tail is still used for on-site additions**) (**the tail is not used**).

3. Complete statements about arrow side, other side significance. Circle the information that best completes each statement.

   a. A weld symbol located beneath the reference line indicates the weld is to be made (**on the opposite side the arrow points to**) (**on the same side the arrow points to**).

   b. A weld symbol located above the reference line indicates the weld is to be made (**on the opposite side the arrow points to**) (**on the same side the arrow points to**).

4. Select true statements about arrow line variations. Place an "X" beside each true statement.

   ______a. A broken arrow line points to the workpiece to be prepared, and is used only on a bevel, no other joint.

   ______b. Multiple arrow lines are used to indicate that three different welding or cutting processes are required in the same place.

Written Test

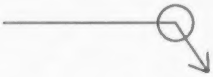
5. Differentiate between weld symbols and welding symbols. Place an "X" beside the definition of a welding symbol.

_______a. This symbol is a shape designed to represent a basic weld.

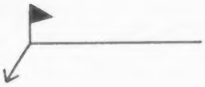
_______b. This symbol is on the reference line along with all other information significant to the weld.

6. Identify supplementary symbols. Write the number denoting the symbol name below the appropriate graphic.

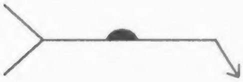
1. Backing
2. Melt through
3. Weld all around
4. Spacer
5. Consumable insert
6. Field weld



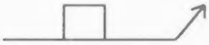
_______a.



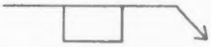
_______b.



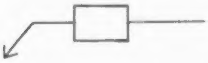
_______c.



_______d.



_______e.

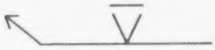


_______f.

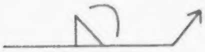
Written Test

7. Identify contour and finish symbols. Write the number denoting the symbol name below the appropriate graphic.

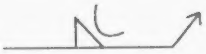
1. Concave contour
2. Finish with grinding
3. Finish with chipping
4. Flush contour
5. Convex contour



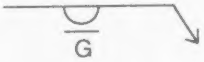
______a.



______b.



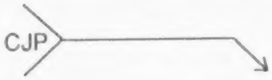
______c.



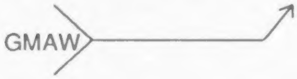
______d.

8. Interpret information in a welding symbol tail. In your own words, state what the following information indicates.

a.



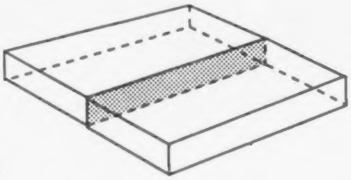
b.



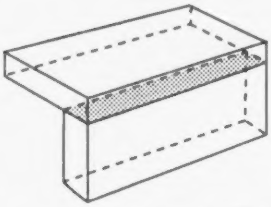
Written Test

9. Identify basic welding joints. Write the number denoting the welding joint beneath the appropriate graphic.

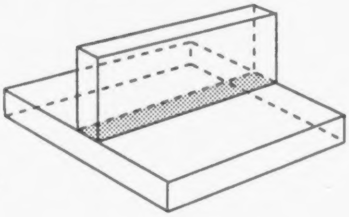
1. T-joint
2. Lap joint
3. Butt joint
4. Edge joint
5. Corner joint



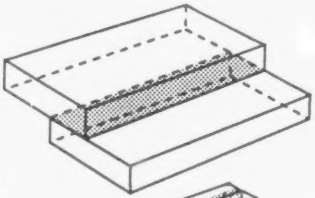
______a.



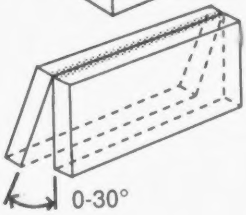
______b.



______c.

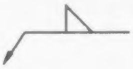


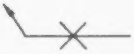
______d.



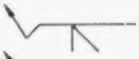
______e.

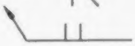
10. Interpret basic welding symbols. With the following illustrations, write the name of the weld and whether it is arrow side, other side, both sides, or either side, and if additional information applies.

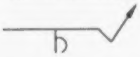
a.  Weld ______________ Added Information ______________

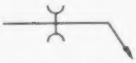
b.  Weld ______________ Added Information ______________

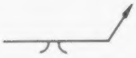
Written Test

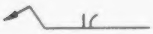
c.  Weld ____________ Added Information ____________

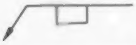
d.  Weld ____________ Added Information ____________

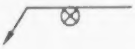
e.  Weld ____________ Added Information ____________

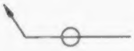
f.  Weld ____________ Added Information ____________

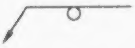
g.  Weld ____________ Added Information ____________

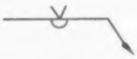
h.  Weld ____________ Added Information ____________

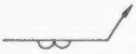
i.  Weld ____________ Added Information ____________

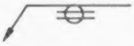
j.  Weld ____________ Added Information ____________

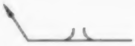
k.  Weld ____________ Added Information ____________

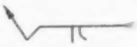
l.  Weld ____________ Added Information ____________

m.  Weld ____________ Added Information ____________

n.  Weld ____________ Added Information ____________

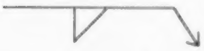
o.  Weld ____________ Added Information ____________

p.  Weld ____________ Added Information ____________

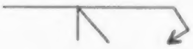
q.  Weld ____________ Added Information ____________

11. Apply basic rules for locating dimensions. Place the dimensions properly in the following welding symbols.

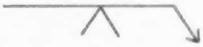
a. Indicate a ¼" weld size on a fillet weld welding symbol.



b. Indicate a ½" groove depth on a bevel groove weld welding symbol.

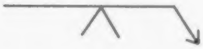


c. Indicate a ⅝" groove depth and a ½" weld size on a v-groove weld welding symbol.

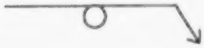


Written Test

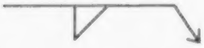
d. Indicate a root opening of ⅛″ and an included angle of 60° on a v-groove weld welding symbol.



e. Indicate that 4 welds should be made on a resistance weld welding symbol.

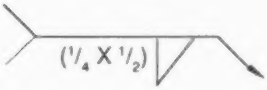


f. Indicate that 4 welds with a 10″ pitch should be made on a fillet weld welding symbol.

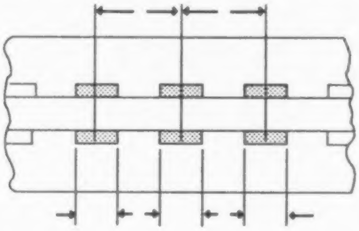


12. Apply additional dimensioning symbols to fillet welds. Place the dimensions properly in the following welding symbols.

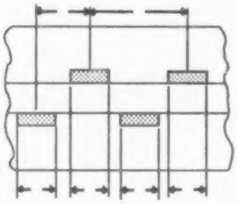
a. Indicate that an unequal leg fillet weld will have a horizontal leg of ½″ and a vertical leg of ½″ and indicate the information will be shown in Detail A, then create Detail A.



b. Indicate that an intermittent fillet weld will have welds 2″ long with a 5″ pitch.



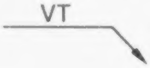
c. Indicate that a staggered-intermittent fillet weld will have welds 3″ long with a 10″ pitch.

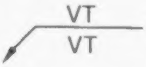


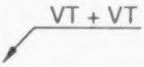
Written Test

13. Interpret nondestructive testing symbols. Select the best interpretation for each of the following testing requirements.

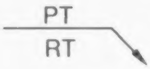
    a. A fillet weld should be visually tested on both sides.

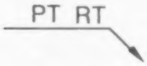
    (1) 

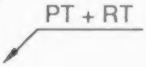
    (2) 

    (3) 

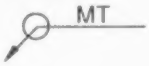
    b. A groove weld requires penetrant testing and radiographic testing.

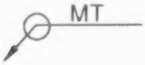
    (1) 

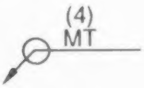
    (2) 

    (3) 

    c. A fillet weld on a pipe requires magnetic particle testing in four specific or random locations.

    (1) 

    (2) 

    (3) 

14. Select true statements about procedures for fitting up and welding structural shapes. Place an "X" beside each true statement.

_______a. Structural shapes of the same or different sizes may be butted for fit-up and welding.

_______b. Structural shapes of only the same sizes may be mitered for fit-up and welding.

_______c. Structural shapes of the same or different sizes may be notched for fit-up and welding.

***Permission to duplicate this test is granted.**

Basic Welding Joints and Symbols
Unit 7

Unit Evaluation Form

Student Name ______________________ Unit Rating ________

Assignment Sheet 1—Identify Basic Weld Symbols Rating ______

Comments: ______________________

Assignment Sheet 2—Interpret Basic Welding Symbols Rating ______

Comments: ______________________

Assignment Sheet 3—Interpret Working Welding Symbols Rating ______

Comments: ______________________

Assignment Sheet 4—Draw Welding Symbols for Given Specifications Rating ______

Comments: ______________________

Assignment Sheet 5—Interpret a Welding Print and Welding Procedures Specifications Rating ______

Comments: ______________________

Written Test Scores

Pretest ______ Posttest ______ Other ______

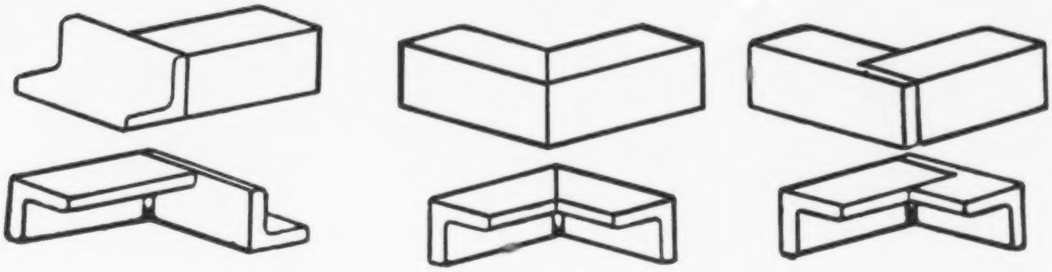
Other ______________________

Teacher Signature ______________________ Date ________

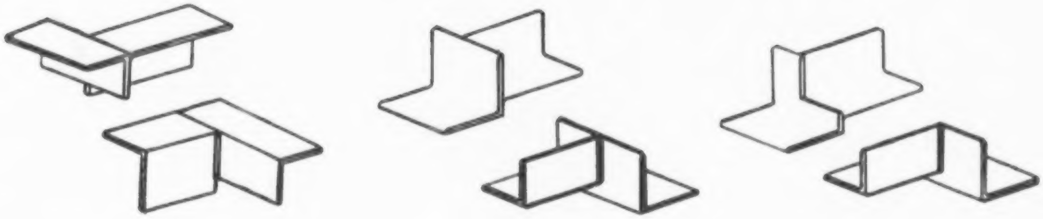
Student Signature ______________________ Date ________

***Permission to duplicate this form is granted.**

Welding Angle to Angle



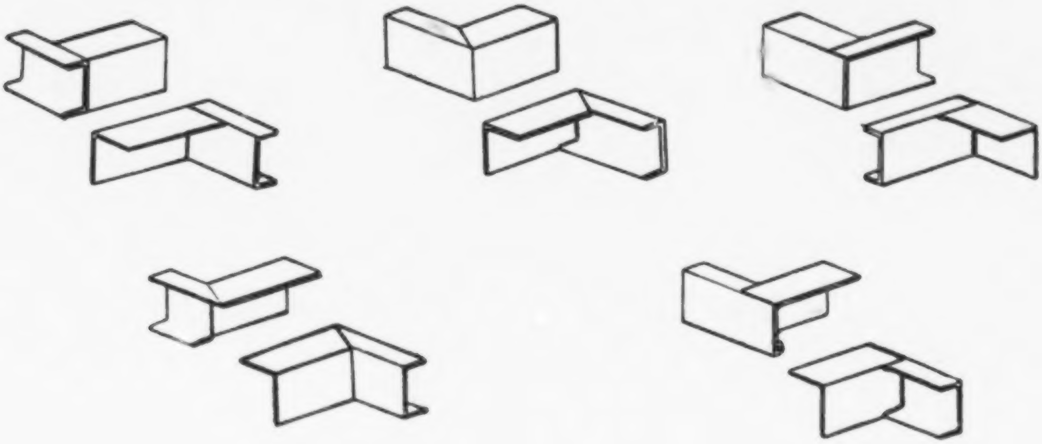
Same Size



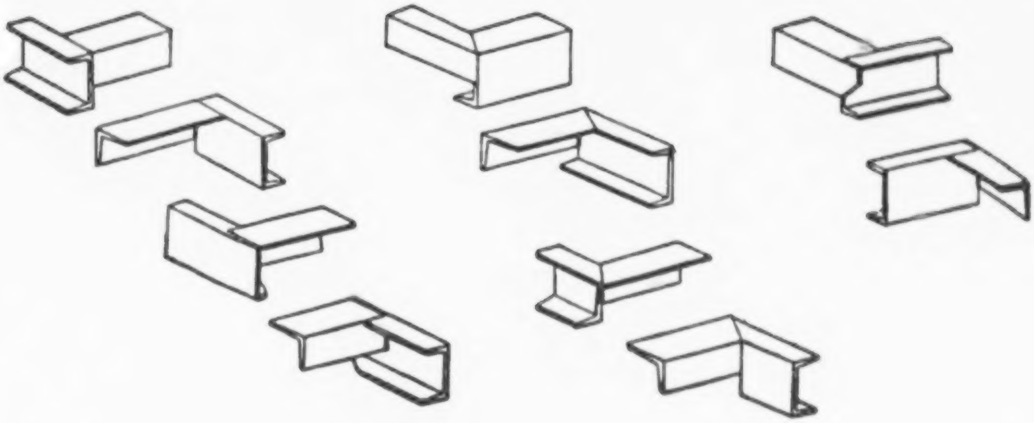
Different Sizes

Courtesy Lincoln Electric Company

Welding Angle to Channel



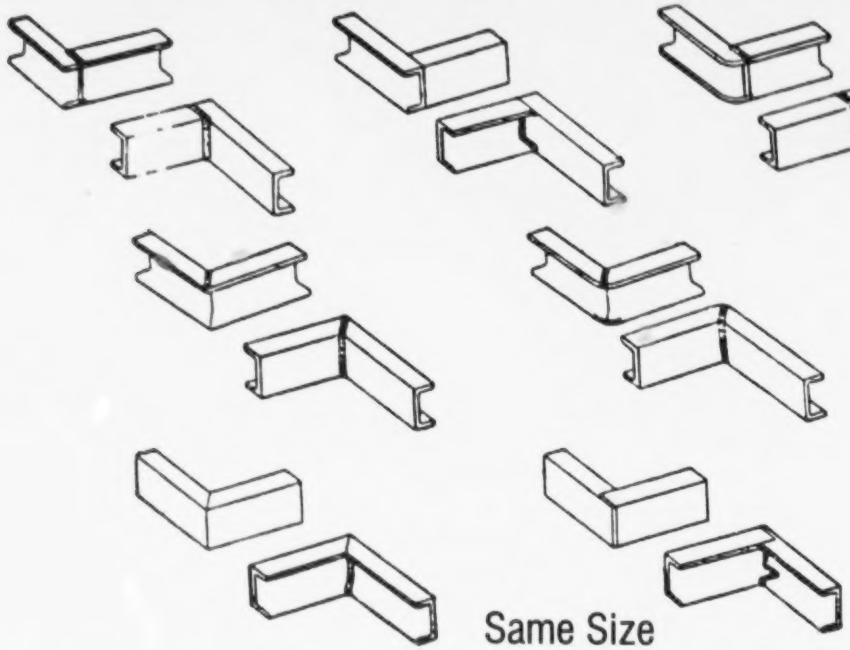
Same Size



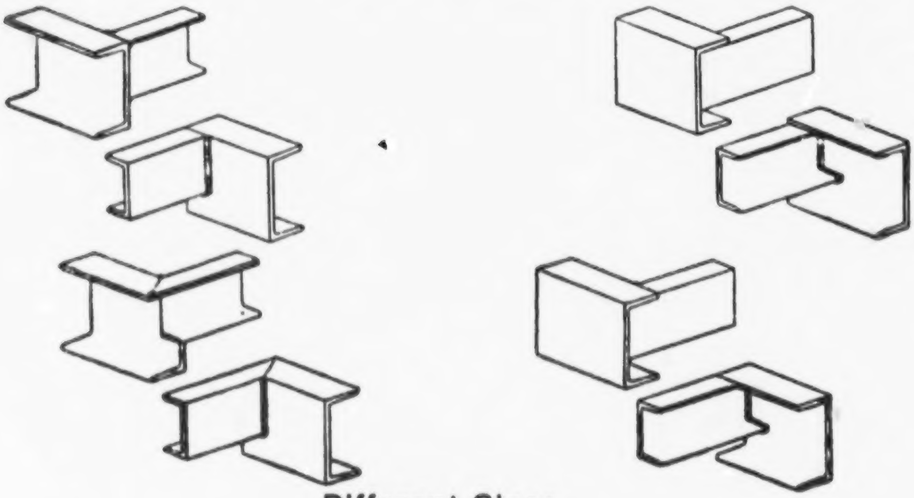
Different Sizes

Courtesy Lincoln Electric Company

Welding Channel to Channel



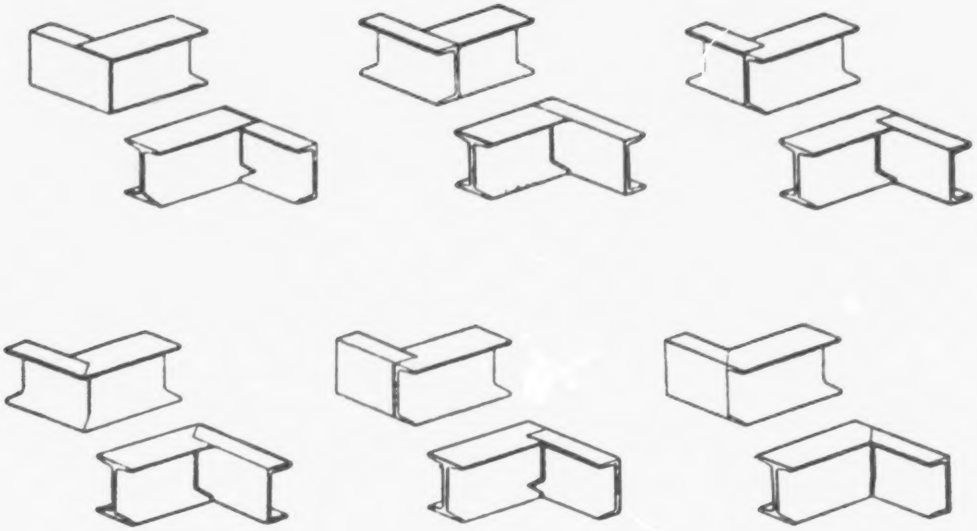
Same Size



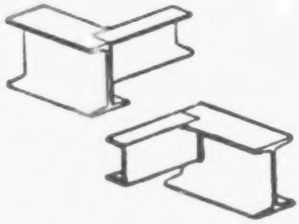
Different Sizes

Courtesy Lincoln Electric Company

Welding Channel to S or W Beams



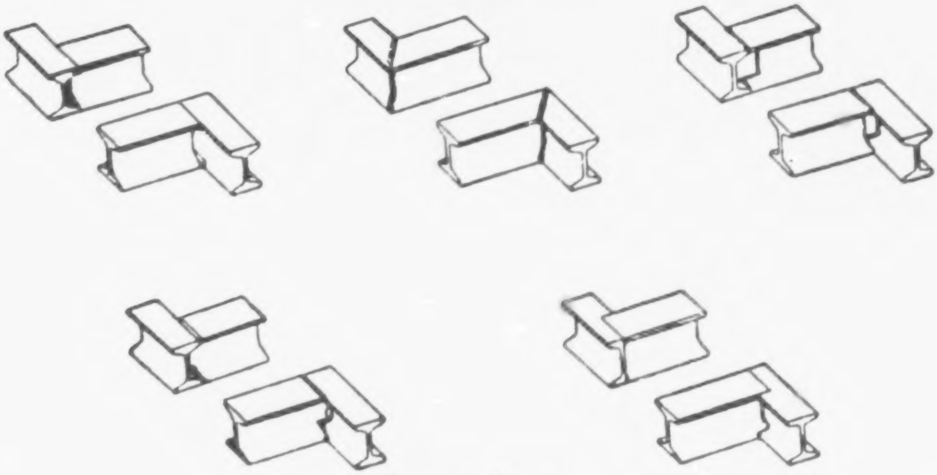
Same Size



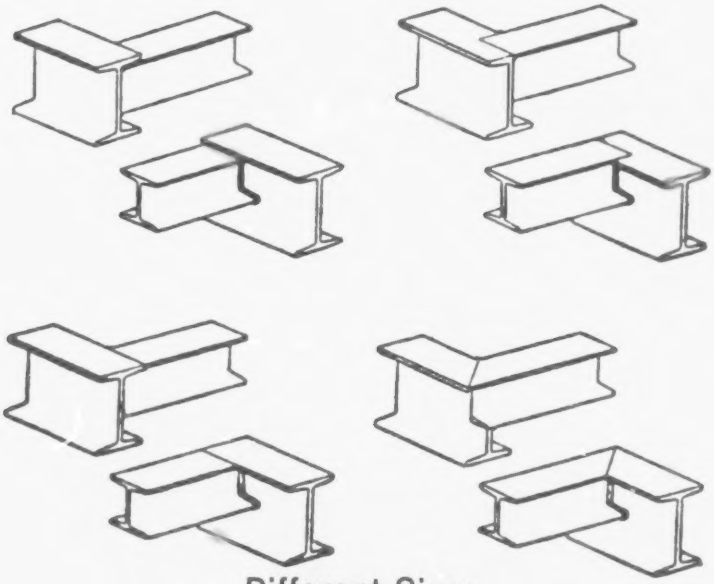
Different Sizes

Courtesy Lincoln Electric Company

Welding S Beams to W or W to S Beams



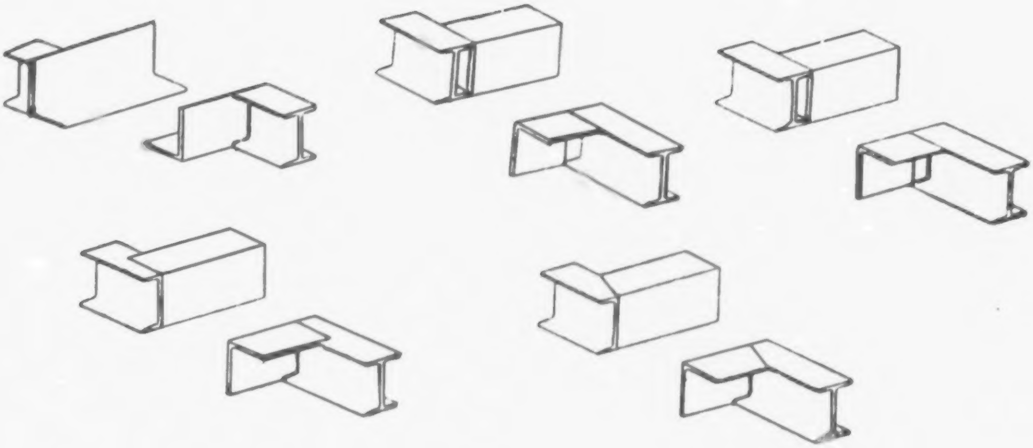
Same Size



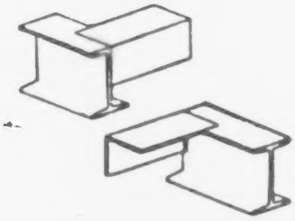
Different Sizes

Courtesy Lincoln Electric Company

Welding Angle to S or W Beams



Same Size



Different Sizes

Courtesy Lincoln Electric Company

Basic Welding Joints and Symbols
Unit 7

Information Sheet

1. **Terms and definitions**

   a. **Concave** — Rounded or curved inward in relation to adjoining planes

   b. **Consumable insert** — Preplaced filler metal that is completely fused into the joint root and becomes part of the weld

   c. **Convex** — Rounded or curved outward in relation to adjoining planes

   d. **Flush** — Forming a relatively level or continuous plane on a surface

   e. **Fillet weld** — A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint

   f. **Groove weld** — A weld made in the groove between workpieces

   g. **Miter** — The beveled edges of workpieces made by cutting two pieces at angles and joining them

   h. **Pitch** — The center-to-center distance between two welds

   i. **Welding symbol** — A graphical representation of a weld

   j. **Weld symbol** — A graphical character connected to the welding symbol indicating the type of weld

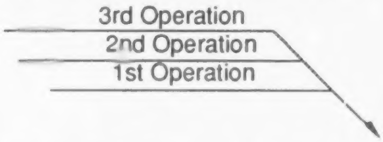
   k. **Workpiece** — The part that is welded, brazed, soldered, thermal cut, or thermal sprayed

2. **Basic parts of a welding symbol**

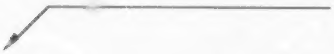
   a. A reference line is a straight line on a horizontal plane with all other welding information located above, below, or on the reference line.

Information Sheet

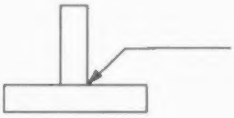
b. Multiple reference lines are used to indicate a sequence of welds or associated activity with the first weld of the series closest the arrow.



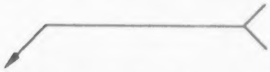
c. An arrow line extends at an angle from either end of a reference line and is terminated with an arrowhead.



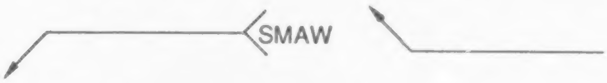
d. The arrow may point in any direction but it always points to the welding joint which requires preparation and/or welding.



e. The tail of a welding symbol is at the end of a reference line, opposite the arrow and it has the horizontal V-shape of feathers at the end of an arrow.

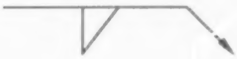


f. The free space in the tail is used for notes, specifications, process, and other items, but if no instructions are required, the tail is not used.

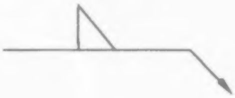


3. Arrow side, other side significance

a. A weld symbol located beneath the reference line indicates the weld is to be made on the same side the arrow points to.



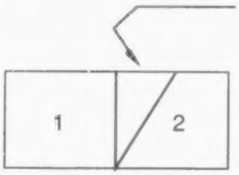
b. A weld symbol located above the reference line indicates the weld is to be made on the opposite side the arrow points to.



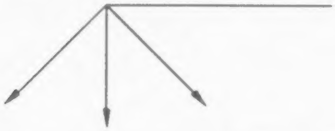
Information Sheet

4. Arrow line variations

a. A broken arrow line points to the workpiece to be prepared, and is used on a bevel, J-joint, flare bevel, and corner flange.



b. Multiple arrow lines are used to indicate that the same weld is required in several different places.

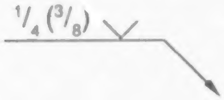


5. Weld symbols and welding symbols

a. A weld symbol is a shape designed to represent a basic weld.

Example: ∨ is V-groove butt weld
◺ is a fillet weld
▭ is a plug or slot weld

b. A welding symbol has the weld symbol on the reference line along with all other information significant to the weld.

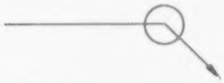


Example: In the graphic above, the v-groove specified should be ¼″ in depth and shall be made on the other side of the joint with a ⅜″ weld.

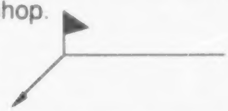
Information Sheet

6. Supplementary symbols

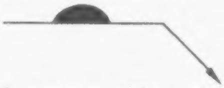
a. The weld all around symbol is an open circle positioned at the junction of the reference line and the arrow line, indicating that the weld is to be made all around the joint.



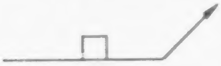
b. A field weld symbol is a darkened flag located at the junction of the reference/arrow lines, indicating the weld is to be made at the job site, not in the shop.



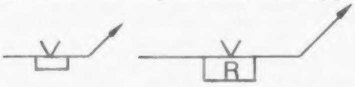
c. A melt through symbol is a solid oval located on the opposite side of the weld symbol, indicating a requirement for 100% penetration.



d. A consumable insert symbol is an open square box located on the reference line, indicating that an insert is consumed in the basic weld.



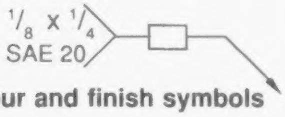
e. A backing symbol is an open rectangular box used in combination with a groove weld symbol; the symbol is located on the reference line, indicating that backing material is required on the opposite side of the weld to control penetration.



f. If backing is to be removed after completion of the weld, there will be an R in the backing symbol.

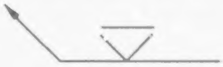
g. A spacer symbol is an open rectangular box that intersects the reference line, indicating that a spacer is required in the joint.

Note: Spacer and backing size and material are normally placed in the tail of the arrow.



7. Contour and finish symbols

a. A flush contour symbol is located on the same side as the symbol and indicates the weld should be made on approximately a flat plane with the surface.



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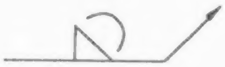
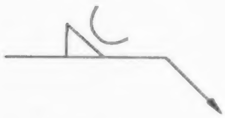
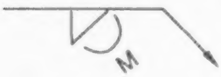
b. A convex contour symbol is located on the same side as the symbol and indicates that the weld should have a raised or convex shape.

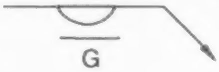


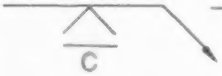
c. A concave contour symbol is located on the same side as the symbol and indicates that the weld should have a depressed or concave shape.

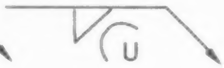


d. If a contour requires finishing, a finishing symbol will be used in conjunction with the contour symbol, a letter G to indicate grinding, C to indicate chipping, M to indicate machining, and U to indicate unspecified which means the best local method should be used.







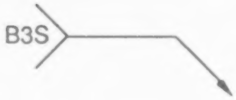


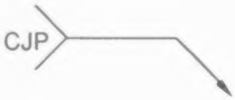
8. **Information in a welding symbol tail**

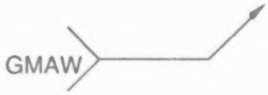
a. When a specification, process, test, or other reference is needed to clarify a welding symbol, the reference is placed in the tail of the welding symbol.

b. The letters CJP (complete joint penetration) indicate that a complete joint penetration groove weld is required regardless of the type of weld or joint preparation.

c. The tail may be omitted when no specifications, process, or other reference is required with a welding symbol.



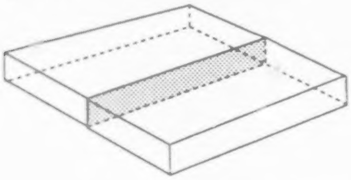




Information Sheet

9. Basic welding joints

a. A butt joint is a joint between two members aligned approximately in the same plane.

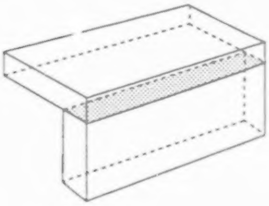


APPLICABLE WELDS

BEVEL-GROOVE
FLARE-BEVEL-GROOVE
FLARE-V-GROOVE
J-GROOVE
SQUARE-GROOVE
U-GROOVE
V-GROOVE
EDGE-FLANGE
BRAZE

Courtesy American Welding Society

b. A corner joint is a joint between two members located approximately at right angles to each other.

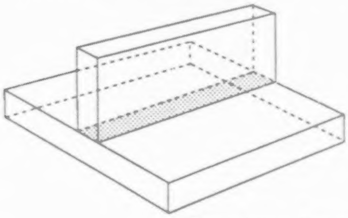


APPLICABLE WELDS

FILLET
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
FLARE-V-GROOVE
J-GROOVE
SQUARE-GROOVE
U-GROOVE
V-GROOVE
CORNER-FLANGE
EDGE-FLANGE
PLUG
SLOT
SPOT
SEAM
PROJECTION
BRAZE

Courtesy American Welding Society

c. A T-joint is a joint between two members located approximately at right angles to each other in the form of a T.

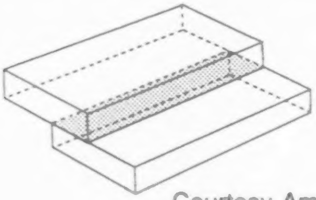


APPLICABLE WELDS

FILLET
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
J-GROOVE
SQUARE-GROOVE
PLUG
SLOT
SPOT
SEAM
PROJECTION
BRAZE

Courtesy American Welding Society

d. A lap joint is a joint between to overlapping members in parallel planes.



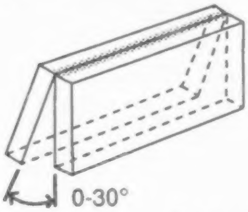
APPLICABLE WELDS

FILLET
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
J-GROOVE
PLUG
SLOT
SPOT
SEAM
PROJECTION
BRAZE

Courtesy American Welding Society

Information Sheet

e. An edge joint is a joint between the edges of two or more parallel or nearly parallel members.



APPLICABLE WELDS

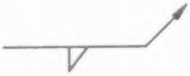
BEVEL-GROOVE
FLARE-BEVEL-GROOVE
FLARE-V-GROOVE
J-GROOVE
SQUARE-GROOVE
U-GROOVE
SEAM
V-GROOVE
EDGE
CORNER-FLANGE
EDGE-FLANGE

Courtesy American Welding Society

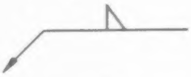
10. Basic welding symbols

a. Fillet weld:

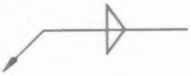
(1) Arrow side:



(2) Other side:

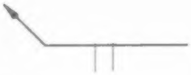


(3) Both sides:



b. Square groove:

(1) Arrow side:



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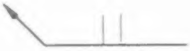
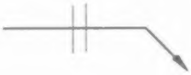
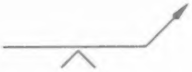


(3) Both sides:



c. V-groove:

(1) Arrow side:



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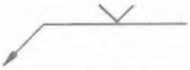
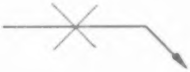


(3) Both sides:



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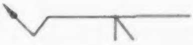
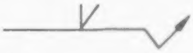
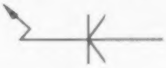
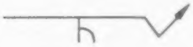
d. Bevel groove:

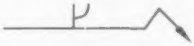
(1) Arrow side: 

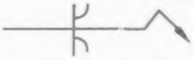
(2) Other side: 

(3) Both sides: 

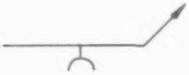
e. J-groove:

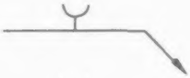
(1) Arrow side: 

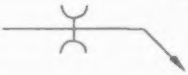
(2) Other side: 

(3) Both sides: 

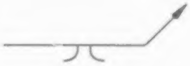
f. U-groove:

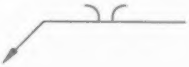
(1) Arrow side: 

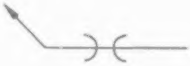
(2) Other side: 

(3) Both sides: 

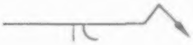
g. Flare V:

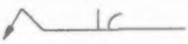
(1) Arrow side: 

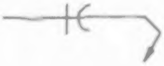
(2) Other side: 

(3) Both sides: 

h. Flare-Bevel:

(1) Arrow side: 

(2) Other side: 

(3) Both sides: 

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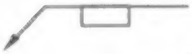
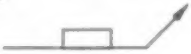
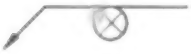
i. Plug or Slot:

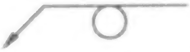
(1) Arrow side: 

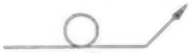
(2) Other side: 

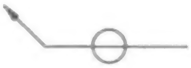
j. Stud:

(1) Arrow side: 

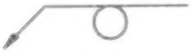
k. Spot:

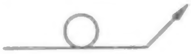
(1) Arrow side: 

(2) Other side: 

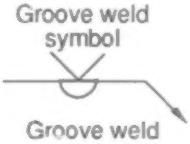
(3) No arrow/other side significance: 

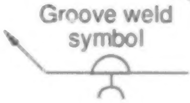
l. Projection:

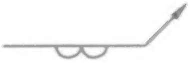
(1) Arrow side: 

(2) Other side: 

m. Back or backing:

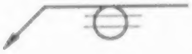
(1) Arrow side: 
Groove weld symbol

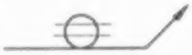
(2) Other side: 
Groove weld symbol

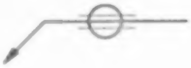
n. Surfacing: Arrow side: 

Information Sheet

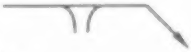
o. Seam:

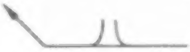
(1) Arrow side: 

(2) Other side: 

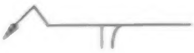
(3) No arrow/other side significance: 

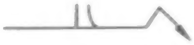
p. Edge flange:

(1) Arrow side: 

(2) Other side: 

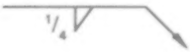
q. Corner flange:

(1) Arrow side: 

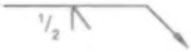
(2) Other side: 

11. Basic rules for locating dimensions

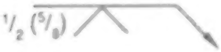
a. Excepting groove welds, the first number to the left of a weld symbol is weld size in inches.



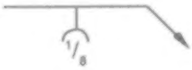
b. The first number to the left of groove weld symbols is groove depth in inches.



c. When a groove weld symbol shows both groove depth and size of weld, the groove depth appears in parenthesis to the left of the symbol and the weld size in inches appears to the left of the parenthesis.

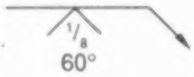


d. The first number inside groove weld symbols is the root opening in inches.

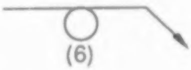


Information Sheet

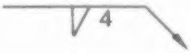
e. The second number inside groove weld symbols is the included angle in degrees.



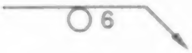
f. On resistance weld symbols, the number (in parenthesis) above or below the symbol indicates the number of welds to be made.



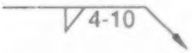
g. The first number to the right of weld symbols, except for circular welds, is length of weld in inches.



h. The first number to the right of circular welds is pitch or center to center distance in inches.

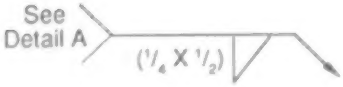


i. The second number to the right of other than circular welds is pitch in inches on center.

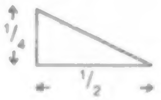


12. Additional dimensioning symbols for fillet welds

a. An unequal leg fillet weld symbol will have a note in the tail referencing a detail drawing that will specify the size for each leg.

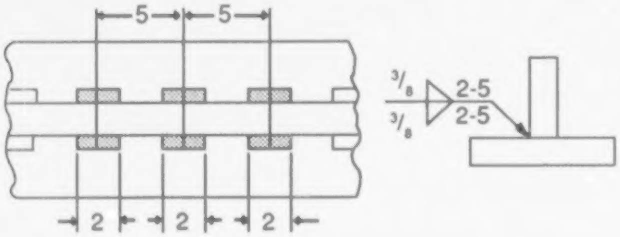


Detail A



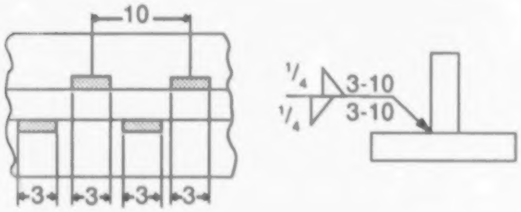
Information Sheet

b. An intermittent fillet weld symbol has numbers to indicate length of the welds and the pitch or center to center distance, and the fillet weld symbol is aligned to indicate welds should be aligned opposite each other.



Courtesy American Welding Society

c. A staggered-intermittent weld fillet weld symbol has numbers to indicate length and pitch, but the fillet weld symbol is staggered on the reference line to indicate the welds should be staggered on each side of the joint.



Courtesy American Welding Society

13. Nondestructive testing symbols

a. Frequently used symbols for nondestructive testing are:

(1) MT—Magnetic particle testing

(2) PT—Penetrant testing

(3) RT—Radiographic testing

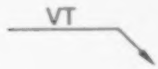
(4) UT—Ultrasonic testing

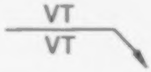
(5) VT—Visual testing

Note: Other less frequently used nondestructive testing symbols are AET—Acoustical emission testing; ET—Electromagnetic testing; NRT—Neutron radiographic testing; and PT—Proof testing.

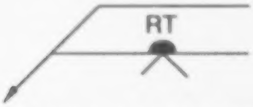
Information Sheet

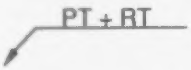
b. Nondestructive testing symbols may appear on or below the reference line, but if the symbol appears on both sides of the reference line, it means both sides of the joint require testing.



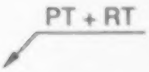


c. Nondestructive testing symbols may be combined with welding symbols or with each other if a welded workpiece is to be checked by two or more methods.

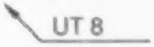


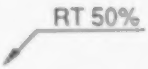


d. When two or more testing methods are required on the same joint, all tests will be listed in sequence with the first test closest the arrow.

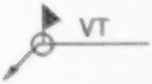


e. The number to the right of the testing symbol indicates length or percentage to be tested, with length meaning length in inches and percentage meaning a portion of the weld related to its total length.

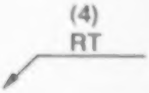




f. The test all around and field tests symbols are the same as their welding symbols, except that they pertain to testing.

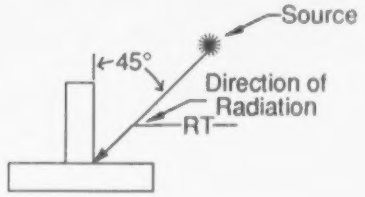


g. The number above or below the testing symbol indicates the number of tests required at specific locations or random selection as specified by contract.



Information Sheet

i. Radiographic testing is so precise that test specifications may require specific test angles and locations and may be so noted in a reference.



14. Procedures for fitting up and welding structural shapes

a. Structural shapes of the same or different sizes may be butted for fit-up and welding.

b. Structural shapes of the same or different sizes may be mitered for fit-up and welding.

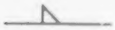
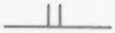
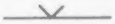
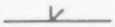
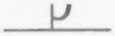
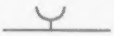
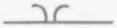
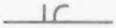
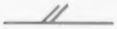
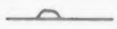
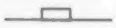
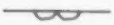
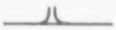
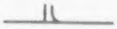
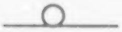
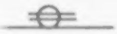
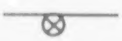
c. Structural shapes of the same or different sizes may be notched for fit-up and welding.

  (1) Angle to angle
  (2) Angle to channel
  (3) Angle to S or W beams
  (4) Channel to channel
  (5) Channel to S or W beams
  (6) S or W to S or W beams

Basic Welding Joints and Symbols
Unit 7

Student Supplement 1—Weld Symbols, Names, and Definitions

Name ____

	Symbol	Name	Definition
1.		Fillet weld	A weld of an approximately trinagular cross section joining two surfaces approximately at right anles to each other in a lap joint, T-joint, or corner joint
		Groove Welds	A weld made in a groove between two workpieces
2.		Square groove weld	Workpieces aligned on approximately a flat plane
3.		V-groove weld	A groove in the shape of a V
4.		Bevel groove weld	When only one or two workpieces are to be grooved
5.		J-groove weld	A groove in the shape of a J on one workpiece
6.		U-groove weld	A groove in the shape of a U
7.		Flare V-groove weld	A groove when both workpieces are to be flared
8.		Flare bevel groove weld	A groove when only one workpiece is to be flared
9.		Scarf groove	A slanted square groove used only for brazing
		Other Welds	
10.		Back or Backing weld	A back weld is distinguished from a backing weld only by the time of application
11.		Plug or Slot weld	A plug weld is distinguished from a slot weld only by the shape of the hole
12.		Surfacing weld	A weld used to build up workpieces for extended life
13.		Edge flange weld	A weld used on the flanged edges of light gage metal
14.		Corner flange weld	A weld used on light gage metal when only one edge of the workpiece is flanged
15.		Spot or projection weld	A spot weld is distinguished from a projection only by the welding process in the tail of the arrow
16.		Seam weld	A continuous spot weld made with circular rotating electrodes
17.		Stud weld	A weld made by joining studs to a metal workpiece for the purpose of anchoring concrete or other poured material

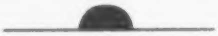
Basic Welding Joints and Symbols
Unit 7

Assignment Sheet 1—Identify Basic Weld Symbols

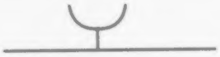
Name ______________________ Overall Rating __________

Evaluation criteria	Rating
Identification of basic weld symbol	______
Arrow side, other side interpretations	______
Significant other information	______

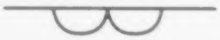
Directions: Study each symbol carefully, then identify the symbol.



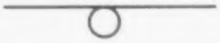
1. ______________________



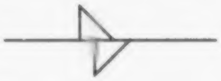
2. ______________________



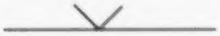
3. ______________________



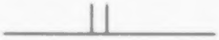
4. ______________________



5. ______________________



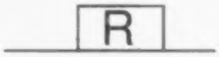
6. ______________________



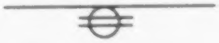
7. ______________________

PT 8

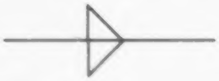
8. ______________________



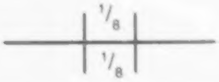
9. ______________________



10. ______________________

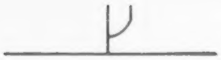


11. ______________________

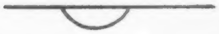


12. ______________________

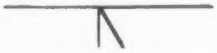
Assignment Sheet 1



13. ______________________________



14. ______________________________



15. ______________________________

Basic Welding Joints and Symbols
Unit 7

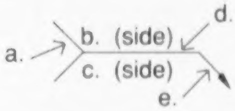
Assignment Sheet 2—Interpret Basic Welding Symbols

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Identification of basic weld symbol	______
Identification of dimensions and sizes	______
Arrow side, other side interpretations	______
Procedure or finishing information	______
Significant other information	______

Directions: Study each of the following welding symbols carefully and interpret all of the items that follow. Be sure to indicate arrow side or other side when identifying the basic weld symbol. Other significant information may include specifications such as backing or weld all around. Be sure to complete all items.

1.



a. ____________

b. ____________

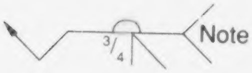
c. ____________

d. ____________

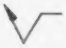
e. ____________

Assignment Sheet 2

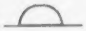
2.

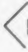


a. ¾ ____________

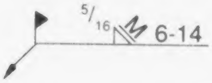
b.  ____________

c. ____________

d.  ____________

e. Note ____________

3.



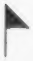
a. 5⁄16 ____________

b. 6 ____________

c. 14 ____________

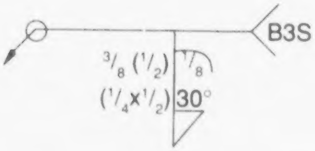
d. ____________

e. M ____________

f.  ____________

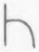
g. ____________

4.


3/8 (1/2)
1/8
(1/4x1/2)
30°
B3S

a. ⅜ ____________

b. (½) ____________

c.  ____________

Assignment Sheet 2

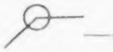
d. ◸ ______________

e. ⅛ ______________

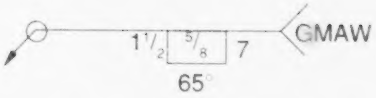
f. 30° ______________

g. (¼ × ½) ______________

h. B3S ______________

i.  ______________

5.



1½
5/8
7
65°
GMAW

a. 1½ ______________

b. ▭ ______________

c. ⅝ ______________

d. 7 ______________

e. 65° ______________

f. GMAW ______________

Basic Welding Joints and Symbols
Unit 7

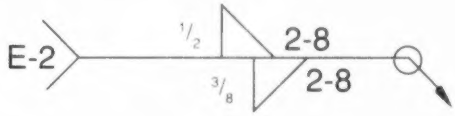
Assignment Sheet 3—Interpret Working Welding Symbols

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Identification of basic weld symbol	_____
Arrow side, other side interpretations	_____
Items of special significance	_____

Directions: Study each of the following welding symbols carefully. Your interpretation should include the weld symbol, sizes, dimensions, and all other items that have significance to a particular symbol. Make your entries in the spaces provided. Make your work easier by reading the symbols in order such as right to left, left to right, arrow to other side, or whatever order seems most appropriate to the interpretation.

1.



____

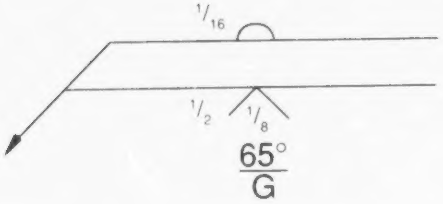
____

____

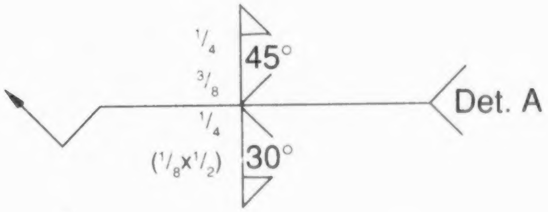
____

Assignment Sheet 3

2.

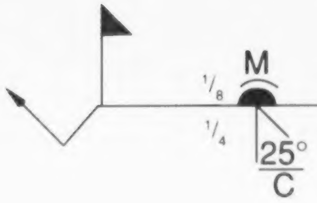

1/16
1/2
1/8
65°
G

3.

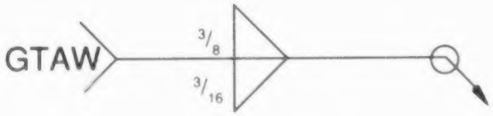

1/4
45°
3/8
1/4
(1/8x1/2)
30°
Det. A

Assignment Sheet 3

4.

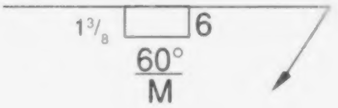


5.

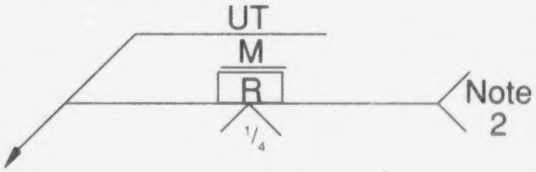


Assignment Sheet 3

6.

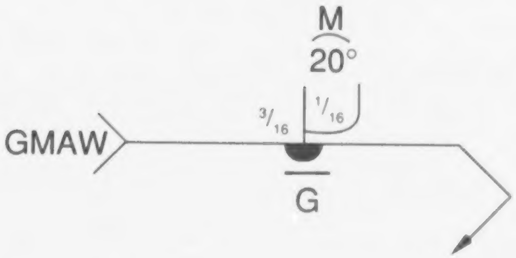


7.

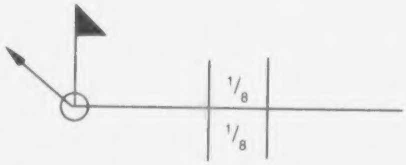

UT
M
R
1/4
Note 2

Assignment Sheet 3

8.

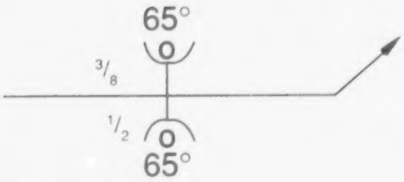

M
20°
3/16
1/16
GMAW
G

9.

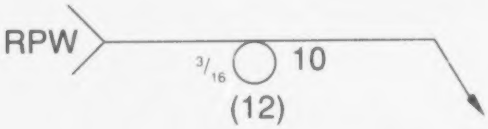


Assignment Sheet 3

10.

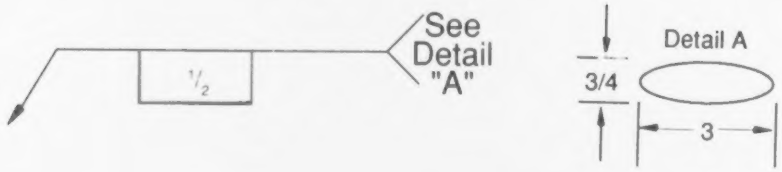


11.

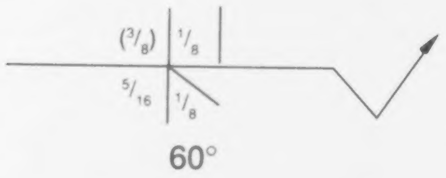

RPW
3/16
10
(12)

Assignment Sheet 3

12.

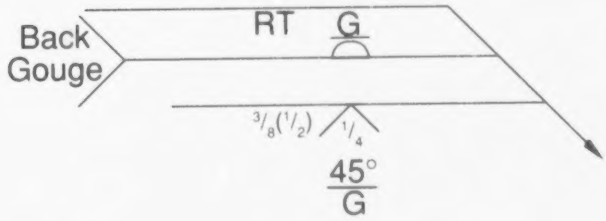

1/2
See
Detail
"A"
Detail A
3/4
3

13.


(3/8)
1/8
5/16
1/8
60°

Assignment Sheet 3

14.


Back
Gouge
RT
G
3/8(1/2)
1/4
45°
G

Basic Welding Joints and Symbols
Unit 7

Assignment Sheet 4—Draw Welding Symbols for Given Specifications

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
Presentation of basic weld symbol	______
Arrow side, other side interpretations	______
Presentation of other significant information	______

Directions: Read the following specifications carefully. Determine arrow side, other side information before your draw the welding symbol. Be sure to put other significant information in the correct positions. Sketch rough symbol on other paper, then place it below the specifications in finished form.

1. Specification: ½" fillet on arrow side, machined convex. ⅜" fillet on other side, grind flush.

2. Specification: ¼" V-groove with ⅜" weld size on arrow side. ⅛" bevel groove with ¼" weld size on other side.

Assignment Sheet 4

3. Specification: A resistance seam weld with a 3000 lb. shear strength. There is no arrow or other side significance.

4. Specification: Other side ⅜″ plug weld, filled ½″ deep with a 30° angle. There should be 10 welds spaced with a 5″ pitch.

5. Specification: An arrow side V-groove weld with a 1⁄16″ root opening, 30° included angle, and a 1⁄32″ back weld on the other side.

6. Specification: An other side bevel groove weld with a ¼″ groove depth and ½″ weld size.

Assignment Sheet 4

7. Specification: An arrow side surfacing weld with a ⅜″ build-up, machined flush.

8. Specification: Six spot welds on the arrow side with ½″ diameter, with a 6″ pitch. Finish flush by grinding and use gas tungsten arc welding.

9. Specification: Six stud welds on the arrow side with a 3″ pitch. ¼″ stud size made with gas metal arc welding.

10. Specification: Square groove with ⅛″ root opening, weld arrow side with melt through. Grind flush on both sides.

Assignment Sheet 5

5. What is the welding current used for welding procedure two?

   a. Alternating
   b. Direct current
   c. Either AC or DC
   d. Direct current, electrode positive

6. On what welds are root openings required?

   a. Bevel groove welds
   b. V-groove welds
   c. Fillet welds
   d. J-groove welds

7. Where should the ¼" leg fillet welds be made?

   a. Arrow side
   b. Other side
   c. Either side
   d. None of the locations in a, b, or c

8. The metal transfer used with the gas metal arc welding process is what kind?

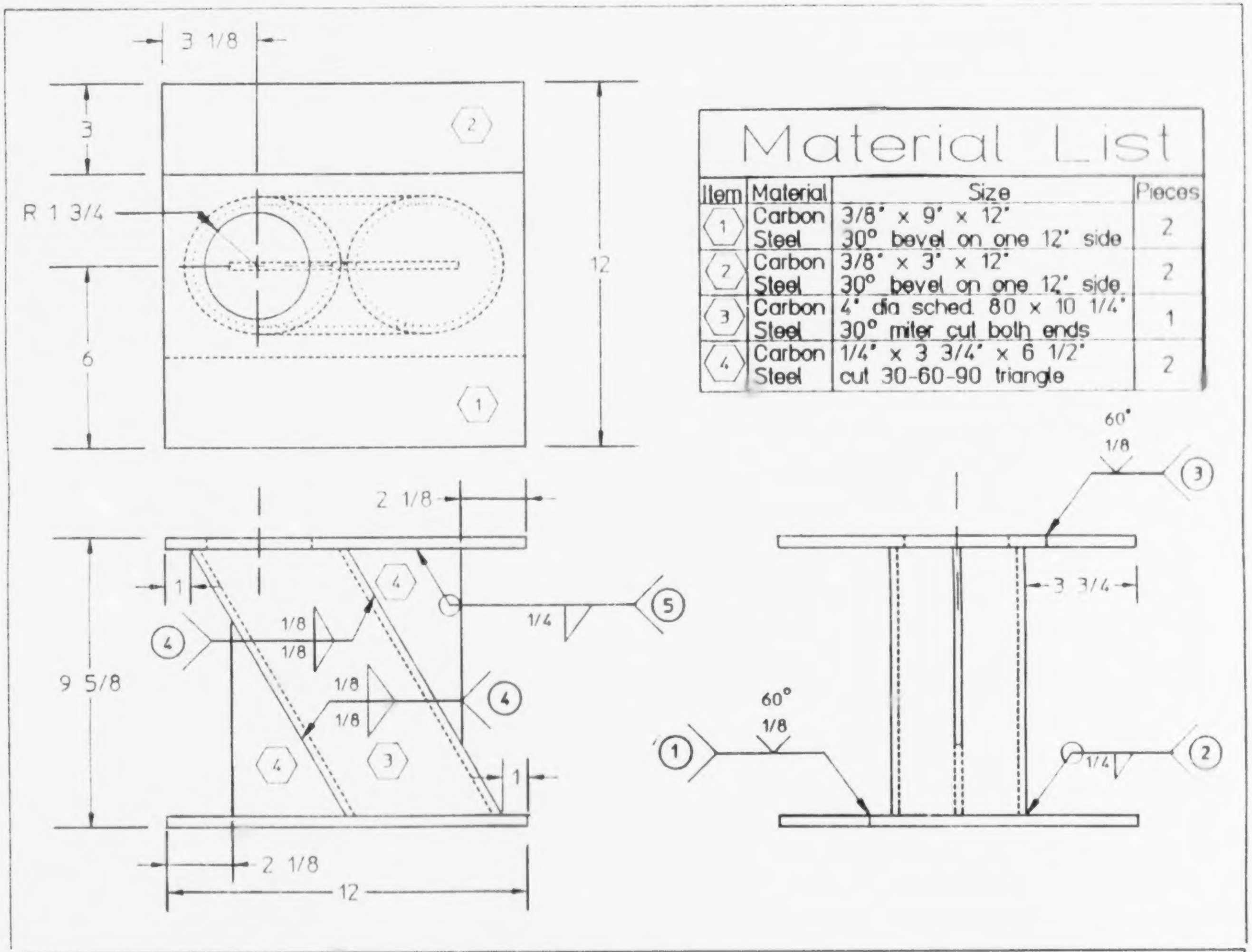
   a. Short circuit
   b. Globular
   c. Spray
   d. Alternating

9. The weld all around symbol is used in what welding procedures?

   a. 1 and 3
   b. 2 and 4
   c. 3 and 5
   d. 2 and 5

10. What AWS class electrodes are used in the shielded metal arc welding process?

   a. E6010 and E7018
   b. E7018 only
   c. E6010 only
   d. E7024 and E7018


3 1/8
3
R 1 3/4
6
12
2 1/8
1
9 5/8
1/8
1/8
1/4
1/8
1/8
1
2 1/8
12
3 3/4
60°
1/8
60°
1/8
1/4
①
②
③
④
⑤

Material List

Item	Material	Size	Pieces
1	Carbon Steel	3/8" x 9" x 12" 30° bevel on one 12" side	2
2	Carbon Steel	3/8" x 3" x 12" 30° bevel on one 12" side	2
3	Carbon Steel	4" dia sched. 80 x 10 1/4" 30° miter cut both ends	1
4	Carbon Steel	1/4" x 3 3/4" x 6 1/2" cut 30-60-90 triangle	2

Welding Print #1

Assignment Sheet 5

FW-297

Assignment Sheet 5

Procedure No. WP - 1

WELDING PROCEDURE SPECIFICATION

Material Specification 3/8" Carbon Steel Plate (ASTM A-36) to 3/8" Carbon Steel Plate (ASTM A-36)

Welding Process GMAW Transfer Mode Spray

Manual -- Semi-Automatic x Automatic -- Machine --

Weld Position: 1 F/G x 2 F/G -- 3 F/G -- 4 F/G -- 5 G -- 6G --

AWS Filler Metal Spec: A 5.18 - 79 AWS Filler Metal Class: ER - 70S - 6

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Argon (89%)/Oxygen (2%) Flow Rate (CFH) 30-40

Passes: Single -- Multiple x Arc: Single x Multiple --

Welding Current: A.C. -- D.C.E.N.(–) -- D.C.E.P.(+) x

Root Treatment 1/8" root opening Backing Material Ceramic Backing Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	.045"	200-290	24-30	300-360	6-13	3/4	Passes - Root & Fill
2							
3							
4							
5							
6							
7							
8							
9							
10							

Assignment Sheet 5

Procedure No. WP - 2

WELDING PROCEDURE SPECIFICATION

Material Specification ⅜" Carbon Steel Plate (ASTM A-36) to 4" dia. Carbon Steel Plate (ASTM A-53) and ½" Carbon Steel Plate (ASTM A-36)

Welding Process GMAW Transfer Mode Spray

Manual -- Semi-Automatic x Automatic -- Machine --

Weld Position: 1 F/G -- 2 F/G x 3 F/G -- 4 F/G -- 5 G -- 6G --

AWS Filler Metal Spec: A 5.18 - 79 AWS Filler Metal Class: ER - 70S - 6

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Argon (98%)/Oxygen (2%) Flow Rate (CFH) 30-40

Passes: Single x Multiple -- Arc: Single x Multiple --

Welding Current: A.C. -- D.C.E.N.(−) -- D.C.E.P.(+) x

Root Treatment N/A Backing Material N/A Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	.045"	200-250	24-30	280-360	6-13	¾	Includes pipe & gusset
2							
3							
4							
5							
6							
7							
8							
9							
10							

Assignment Sheet 5

Procedure No. WP - 3

WELDING PROCEDURE SPECIFICATION

Material Specification 3/8" Carbon Steel Plate (ASTM A-36) to 3/8" Carbon Steel Plate (ASTM A-36)

Welding Process SMAW Transfer Mode N/A

Manual x Semi-Automatic -- Automatic -- Machine --

Weld Position: 1 F/G x 2 F/G -- 3 F/G -- 4 F/G -- 5 G -- 6G --

AWS Filler Metal Spec: A 5.18 - 81 AWS Filler Metal Class: E7018

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition ______ Flow Rate (CFH) N/A

Passes: Single -- Multiple x Arc: Single x Multiple --

Welding Current: A.C. x D.C.E.N.(–) -- D.C.E.P.(+) x

Root Treatment 1/8" root opening Backing Material Ceramic Backing Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	1/8"	90-140 AC or DC			7-14		Passes - Root & Fill
2							
3							
4							
5							
6							
7							
8							
9							
10							

Assignment Sheet 5

Procedure No. WP - 4

WELDING PROCEDURE SPECIFICATION

Material Specification 1/4" Carbon Steel Plate (ASTM A-36) to 4" dia. Carbon Steel Plate (ASTM A-53)

Welding Process GTAW Transfer Mode N/A

Manual x Semi-Automatic -- Automatic -- Machine --

Weld Position: 1 F/G -- 2 F/G -- 3 F/G up 4 F/G -- 5 G -- 6G --

AWS Filler Metal Spec: A 5.18 - 79 AWS Filler Metal Class: ER - 70S - 6

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition Argon Flow Rate (CFH) 10-15

Passes: Single x Multiple -- Arc: Single x Multiple --

Welding Current: A.C. -- D.C.E.N.(–) x D.C.E.P.(+) --

Root Treatment N/A Backing Material N/A Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	3/32	90-190			8-14		Use 3/32" dia. filler metal
2							Electrode AWS Spec. 5. EW Th-2
3							
4							
5							
6							
7							
8							
9							
10							

Assignment Sheet 5

Procedure No. WP - 5

WELDING PROCEDURE SPECIFICATION

Material Specification ⅜″ Carbon Steel Plate (ASTM A-36) to 4″ dia. Carbon Steel Plate (ASTM A-53) and ¼″ Carbon Steel Plate (ASTM A-36)

Welding Process SMAW Transfer Mode N/A

Manual x Semi-Automatic -- Automatic -- Machine --

Weld Position: 1 F/G -- 2 F/G -- 3 F/G -- 4 F/G x 5 G -- 6G --

AWS Filler Metal Spec: A 5.1 - 81 AWS Filler Metal Class: E7018

AWS Flux Spec N/A Weld Metal Grade N/A

Shielding Gas Composition N/A Flow Rate (CFH) N/A

Passes: Single x Multiple -- Arc: Single x Multiple --

Welding Current: A.C. -- D.C.E.N.(−) -- D.C.E.P.(+) x

Root Treatment N/A Backing Material N/A Backgouging N/A

Preweld Heat Treatment NONE Preheat Temperature NONE

Interpass Temperature NONE Postweld Heat Treatment NONE

Pass No.	Electrode Diameter (in.)	Welding Characteristics		Wire Feed Speed (IPM)	Travel Speed (IPM)	Stickout (in.)	Remarks
		Amperage	Volts				
1	⅛″	90-140 DC			7-14		Includes pipe & gusset
2							
3							
4							
5							
6							
7							
8							
9							
10							